SCIENCE TEACHER'S WORLD

For Teachers of Science
PLEASE ROUTE TO:

Teacher's edition of SCIENCE WORLD February 17, 1960

Using *Science World* in Your Teaching

Secrets of the Big Ice (pp. 5-9)

Earth Science Topics: Glacier formation, glacier flow, glacial erosion
Chemistry Topics: Ionic and covalent bonding, crystal structure, alloys
Physics Topics: Change of state, deformation of plastic materials

About This Article

Glaciers and glaciation constituted an important phase of the recent International Geophysical Year and one that is being actively continued at the present time. Many of the great circle air routes lie across the vast icy stretches of the earth's antipodes. The study of glacial ice and glacial movement may therefore prove to be of great significance.

This article presents some of the theories that are emerging from current glacial studies to explain observed glacial phenomena. Glacial formation, glacial flow, the metamorphosis of snow into glacial ice, and the properties of glacial ice itself are interpreted in terms of the chemistry and physics of water.

Teaching Suggestions

As motivation for reading the article, and as a basis for reports to the class, the following assignments might be made:

A. Here are some false ideas about glaciers; from facts presented in the article, refute each statement:

1. A glacier is more likely to be formed in the northern rather than in the southern part of any country in the northern hemisphere.
2. Glaciers are not found near the Equator.
3. Where glaciers exist, it is always wintry cold.
4. Any very deep snow that lies on top of a mountain is a glacier.
5. Ice can not be colder than the freezing point of water.
6. A glacier is solid ice and snow.
7. Glaciers remain in one place for hundreds of years.

B. Explain each of the following:

1. How atoms are held together to form a water molecule.
2. Why snow flakes are six-pointed.
3. How snow changes to glacial ice.
4. How a glacier flows.
5. How glacial ice may be "artificially" hardened.

Cell Differentiation (pp. 10-12)

Biology Topics: Embryonic development, genetics

About This Article

Few things in nature are as marvelous to behold, or as difficult to explain, as the development of an animal from an egg. Only after experimentation had become firmly established and had proved so fruitful in *general* physiology, did investigators attempt experiments in *developmental* physiology. The pioneering experiments of Wilhelm Roux and Hans Driesch and the later experiments of Hans Spemann opened up the field of experimental embryology to hundreds of workers, who to this day are seeking explanations of embryonic growth and differentiation.

The biology teacher whose teaching of animal development is confined to mere description, without the play of ideas involved in classical and present-day experimentation in this field, is depriving his students of a glimpse into one of the most exciting branches of biology. This article is, in a sense, a report on some of the experimentation now going on in this field and some of the ideas on which these experiments are based.

Teaching Suggestions

To enable students to comprehend this article, they should be made familiar with the basic facts of gametogenesis, fertilization, and early cleavage stages in embryonic development. The teacher might then describe the experiments of Hartwig, who used a hair-loop to constrict, or even completely to separate, the cells of a two-cell-stage developing embryo of the sea urchin. Next in order might be a description of some of the "simpler" transplantations of primordial embryonic tissues in amphibian embryos (for the biology teacher, the following book is highly recommended: Spemann, Hans, *Embryonic Development and Induction,* Yale U. Press). With the above as a background, students should find this article fascinating reading. Should assignments be given to individual students for class presentation and discussion—reports based on this article—here is a suggested list:

1. Experiment of Dr. Sven Horstadius.
2. Experiment of Dr. Mabel Paterson.
3. Experiments of Dr. Hans Spemann.
4. Experiments at the University of Illinois.
5. Experiments of Dr. John T. Bonner of Princeton University.

The Mightiest Magnet (pp. 13-16)

General Science Topics: Magnets, the compass, earth magnetism

Physics Topics: Electromagnetic induction, the magnetometer and magnetograph, cosmic rays, the Van Allen belts

Earth Science Topics: The Earth's interior, methods of mineral prospecting

About This Article

In "The Mightiest Magnet," the author draws an epic panorama featuring an invisible "fluid"—magnetism—that permeates and surrounds the Earth—a "fluid" that responds to explosions in the distant sun and that traps showers of nucleons glowing in auroral splendor. Methods of detecting changes in the Earth's magnetic field are described—not only changes observed today, but changes that took place millions of years ago. (Some of these changes in the past stagger the imagination.) Modern theories are presented to account for the Earth's magnetic field and for the changes observed in this field. Finally, the article describes how the magnetometer, suspended from an airplane and reflecting subtle variations in the Earth's magnetic field as the plane flies low over the Earth, yields information of vital interest to the vulcanologist, the petrologist, and the mineral prospector. With the discovery of the Van Allen belts, a "structure" of the Earth's magnetic field is emerging—a structure that is even now being further explored.

For Class Reports and Discussion

1. Explain the work of the Central Radio Propagation Service of the Bureau of Standards.
2. Describe the effects that the solar flare of Feb. 9, 1958, had on magnetographs in various parts of the United States.
3. Give a possible explanation for the effect of solar flares on the Earth's magnetic field.
4. Of what practical importance are violent changes in the Earth's magnetic field?
5. Explain why present-day scientists do not agree with Sir William Gilbert's views concerning the "cause" of the Earth's magnetic field.
6. Describe a modern theory to account for the Earth's magnetic field.
7. A record of past changes in the Earth's magnetism is contained in rocks —explain.
8. Describe the "bird" method of prospecting for oil and other minerals.
9. Explain the relationship between the Earth's magnetic field and the Van Allen belts of radiation.

Exploring Behavior (p. 38)

Biology Topic: Animal Behavior

About This Article

A scientist is one who seeks explanations of natural phenomena. His search for explanations rests on the assumption, based upon past experience, that explanations of natural phenomena are possible to achieve. Now, the behavior patterns of animals—indeed, even *human* behavior—are natural phenomena. Perhaps, therefore, they can be "explained." (What constitutes an *explanation* is an absorbing philosophical question we must leave for another issue of *Science Teacher's World.)*

The present article describes the work of Dr. Harry F. Harlow, in which he attempts by experimental methods to explain the behavior of the infant rhesus monkey toward its mother, and the effect of the mother on the behavior of the infant. The article affords the biology teacher an opportunity to introduce his students to a field of investigation in which biology and psychology meet. Moreover, it affords an opportunity to point out the part that creative imagination plays in the design of an experiment.

Teaching Suggestions

One way to introduce a class to the study of animal behavior is to place an animal such as a rat or a frog in a large battery jar on the demonstration table and ask the class to observe the animal for five minutes and to record its behavior. It is surprising how difficult it is for the beginner to describe behavior *objectively* without ascribing human motives to the animal. Thus students will often record such observations as "the frog wanted to jump out."

Having learned a lesson in *objective* description, a pupil may be ready for the next step—to discover that a given species of animal may exhibit behavior that is characteristic of the species. For example, fruit flies move toward light, and they move away from the pull of gravity. Here, in a sense, is an "explanation" of the behavior of a single fruit fly in a given environment. But, like all scientific explanations, this one raises more questions than it answers—questions that are, in fact, invitations to experiment. For example, in what direction will a fruit fly move when it is placed in an environment where the light shines from below? To which of the many wave lengths of which white light is composed is the fly responding?

With such experiences as have been described above, the pupil might then be referred to the present article on the work of Dr. Harlow with rhesus monkeys. A word of caution, however, is in order: We must point out emphatically the fallacy of carrying over to humans what we learn about the behavior of animals. Any inference of this sort must be held in abeyance until confirmed by the study of the behavior of man himself.

Tomorrow's Scientists (pp. 39-42)

Crystallography (James Birk)

A Secondary Time Source (William McGinnis)

An exposure to chemistry in which theory exceeds first-hand experience is not likely to "take"; an exposure to chemistry in which first-hand experience is tied to theory *is* likely to "take." James Birk's conception of ions, ionic solutions, ionic movement, ionic change, and ionic bonding are all the more real and meaningful to him because of his first-hand experience in growing crystals of "ten different salts in 44 different solutions."

James Birk's project might well be held up to a science class as an example of a piece of diligent and persevering work. Among points that deserve emphasis are these: (1) He was not stymied when faced with difficulties—problems in suspending his crystals, problems with variations in temperatures of his solutions, and the like, which he managed to overcome. (2) His work was quantitative; he took the trouble to weigh and to measure and thus arrived at the rate of crystal growth and variations in the rate of crystal growth. (3) His *brain* was working as well as his hands ("my hypothesis is that they grow so fast that the bond between them is weak"). At the same time, he was in no hurry to jump to a conclusion ("I will have to repeat this experiment several times before I can be sure of the explanation"). (4) He was alert to identify new problems growing out of his work—the effect of the growth of one crystal on another.

The next best to real experience is *vicarious* experience. James' report might profitably be made a "text assignment" for chemistry classes studying ionic bonding and crystal structure.

William McGinnis's Project—"A Secondary Time Source"—will commend itself to physics students studying alternating current, the piezoelectric effect, and crystal oscillators.

Science in the News (pp. 33-36)

Several of the news articles aptly illustrate laboratory technique; e.g., how the Stanford scientists solved the problem of spurious radio noises.

Our Place in Space

THE spirit of adventure—to go places and to do things—these are the earmarks of youth. For this reason, this booklet in the General Electric *Adventures in Science* Series will be gobbled up by students, by their older brothers and sisters, and—perhaps even by their parents.

In this special insert, two boys, coming away from a science-fiction movie, become interested in space and spacemen. An older brother of one of the boys brings them around from fiction to reality and does an excellent job in developing the idea of a rocket as something quite natural—an object thrust by a force and subject to gravity and inertia. What is more, he points out that rockets are not entirely new; they were used as far back as 1232 A.D. by the Chinese, they were used by ancient Roman warriors, and even by our own Navy in the War of 1812. During World War II, rockets were developed powerful enough to be shot across the English channel from the European continent.

The boys in this narrative then view a TV show from which they learn the structure of a Vanguard rocket. They learn the various uses for which rockets are built, and they hear that the most exciting and complicated rockets are being built for space exploration.

The boys go on a tour through several manufacturing plants where they learn the great variety of devices that must be built and operated for space exploration—electronic equipment for guidance systems and for data gathering, antennae and amplifiers for receiving signals from space probes as much as 407,000 miles away, guidance trackers, and the like. The boys learn, too, about new materials—propellants, ceramics, and alloys that can withstand the conditions encountered by rockets in and beyond the Earth's atmosphere. Finally, the boys visit establishments where research is going on to help solve the many problems of putting man into space—problems of body protection, food and oxygen supply, and re-entry.

Teaching Suggestions

Although the booklet is most suitable for general science students, it runs the gamut of the sciences—physics, chemistry, biology, earth science—and can be read with profit by all students. For example, in physics classes, it can be read in connection with the study of Newton's laws of motion, the laws of falling bodies, friction, ablation, electromagnetic waves, and electronics; in chemistry classes it can be read in connection with combustion, metals and their alloys, ceramics; in biology classes, in connection with photosynthesis and space physiology; in earth science in connection with the Earth's atmosphere.

Topics for Class Reports and Discussion

1. Forces at work on a man-made satellite from the time it leaves the ground to the time it returns to Earth.
2. What is inside a Vanguard rocket.
3. What must be done before a completed rocket is launched?
4. What each of the following specialists contributed to space exploration through rockets: mathematicians, physicists, chemists, biologists, engineers.
5. Devices used in guiding and in tracking rockets.
6. How space vehicles are recovered after re-entry.
7. Problems that have to be solved before man can leave the Earth's atmosphere and return alive.

Advertisement

Ideas for Science Clubs

AT a recent Science Clubs of America conference of club sponsors from Washington, D. C., and nearby areas in Maryland and Virginia, dozens of successful ideas were reported from the various clubs. Many of these are practical almost anywhere. Others would take a little "custom tailoring" to make them fit your particular club's geographical location and other individual circumstances.

One junior high school club has taken up ham radio as a special project, using discarded U. S. Army equipment and being instructed by Army personnel. Twenty-seven members of the club now have earned their licenses. Another group within the club has formed an astronomy section that holds weekly lecture and discussion meetings and monthly observing sessions. Still another group is concentrating on a weather project carried out in cooperation with the U. S. Weather Bureau.

The weekly assembly meeting held by this club is open to all students in the school and draws an audience of some 200 each Wednesday afternoon. An advertising layout specialist from a local department store was invited to speak at one of the meetings, offering expert advice on exhibit techniques useful to science fair projecteers.

Another junior high school club puts on a "Greens Show" each year. Students bring in living greens which the club members identify, label and display in a case.

A senior high school club puts particular emphasis on lively contact with junior high school and elementary school students. Committees are set up by the club to help the younger students in planning and carrying out science projects and other science activities, and to invite them to become members of the science club when they reach high school.

If your science club or class has not had the experience of carrying out a project or special activity under the guidance of professional scientists, you may want to investigate the possibilities in your area. Many professional organizations, both government and private, are prepared to help your club. Many more would be eager to cooperate if they knew exactly the kind of help you and your students could use.

The charter ceremony described in this report could be an effective means of emphasizing the place of the science club in the activity program at your school. Such recognition might stimulate the interest efforts of the members and of the entire student body.

In order to be a member in good standing of one Maryland club, each student must participate in some kind of research. This is not necessarily a science project suitable for entering in a science competition. It may be an activity such as the one carried out by a girl who made and distributed to the faculty an annotated list of all the science and mathematics books in the school library.

In an especially impressive annual ceremony at this high school, the principal formally presents the Science Clubs of America charter to the president of the science club. Each member then stands to indicate his acceptance of the pledge and receive his membership card. Such a ceremony adds status and meaning to club membership, and gives special recognition to the importance of the club's activities, the sponsor reported.

If your club activities offer ideas for other clubs, or if your club decides to adapt some of the ideas just described, share the news with science clubs all over the world. Send your news to Science Clubs of America at Science Service, 1719 N Street, N. W., Washington, D. C.

PROGRAM SCHEDULE—1960 CONVENTION

"Current Science and the K-12 Program"

Kansas City, Missouri

Tuesday, March 29	Wednesday, March 30	Thursday, March 31	Friday, April 1	Saturday, April 2
9:00 a.m. Registration 10:00 a.m. Supervisors' Section: General Session 10:00 a.m. Association for Education of Teachers in Science (AETS): General Session. Dr. J. Stanley Marshall, speaker	8:30 a.m. Teaching Demonstrations in Schools 9:00 a.m. Registration 9:00 a.m. Exhibits 9:00 a.m. Tours 9:00 a.m. AETS: General Session 9:00 a.m. Supervisors' Section: Concurrent Sessions 10:30 a.m. Film Showings 11:00 a.m. Supervisors' Section: General Session	8:00 a.m. Registration 8:00 a.m. Exhibits 8:00 a.m. Film Showings 9:00 a.m. **Third General Session:** "How a K-12 Program Develops," Dr. Robert H. Johnson, speaker 11:00 a.m. Current Efforts in Curriculum Redesign. Symposia (5)	8:00 a.m. Registration 8:00 a.m. Exhibits 9:00 a.m. **Fifth General Session:** "Teacher Education for a K-12 Program," Dr. Leona M. Sundquist, speaker 11:00 a.m. Pre-Service Education Panels (5) 11:00 a.m. In-Service Education Panels (5)	7:30 a.m. Life Members' Breakfast 8:00 a.m. Registration 8:00 a.m. Exhibits 8:00 a.m. Film Showings 9:30 a.m. **Sixth General Session:** "K-12 in Relation to the Total School Program," Dr. John H. Fischer, speaker 10:30-noon Summary and Exhibits of Parallel Workshops* 11:00 a.m. K-12 Curriculum Swapshop and Consultant Service 11:00 a.m. Student Exhibit Display
12:15 p.m. Supervisors' Luncheon. Dr. Harold Boda, speaker		12:30 p.m. B-I-E Luncheon. Dr. Walter H. Brattain, speaker "The Essence of Science & Science Teaching—A Personal View"	12:30 p.m. Elementary Science Luncheon. Dr. Joe Zafforoni, speaker "Case of Mrs. Doe"	12:30 p.m. Missouri Science Teachers Association Luncheon, speaker
2:30 p.m. Supervisors' Section: Concurrent Sessions 4:00 p.m. Early Bird Mixer	1:30 p.m. **First General Session:** "The Ecology of the Educational Community," Dr. Donald G. Decker, speaker 3:00 p.m. Tea for Wives 3:30 p.m. Meeting of Chairmen and Recorders for all Sessions 5:00 p.m. Western Hospitality Hour and Buffet Supper	2:00 p.m. General Session for Workshop Participants 2:30 p.m. Tours 3:00 p.m. Parallel Workshop Sessions (4)* 3:00 p.m. Concurrent Panels (12) 3:00 p.m. K-12 Curriculum Swapshop and Consultant Service	1:30 p.m. Frontiers of Science Concurrent Sessions (5) 2:00 p.m. Student Exhibit Displays 3:00 p.m. Parallel Workshop Sessions—Second Session* 3:00 p.m. "Here's How I Do It" Elementary Sessions 3:30 p.m. Frontiers of Science Concurrent Sessions (5)—Repeat session	2:15 p.m. "Here's How I Do It" Sessions (6)
8:00 p.m. Supervisors' Section: Business Meeting	8:00 p.m. **Second General Session:** Frontiers of Science series. Dr. Linus C. Pauling, speaker "High-Energy Radiation and its Effects on Man" Introduction of new NSTA officers and directors	8:00 p.m. **Fourth General Session:** Frontiers of Science series. Dr. John R. Heller, speaker "Progress in Cancer Research" Presentation of STAR '60 awards	7:00 p.m. Annual Banquet: Frontiers of Science series. Dr. George B. Kistiakowsky, speaker "Science and Citizenship"	

★ **PARALLEL WORKSHOPS**

A. Teaching about Plants and Animals and How They Grow; B. Teaching about Electricity and Magnetism; C. Exploring the Changing World; D. Using Special Resources in Teaching Science.

SCIENCE WORLD

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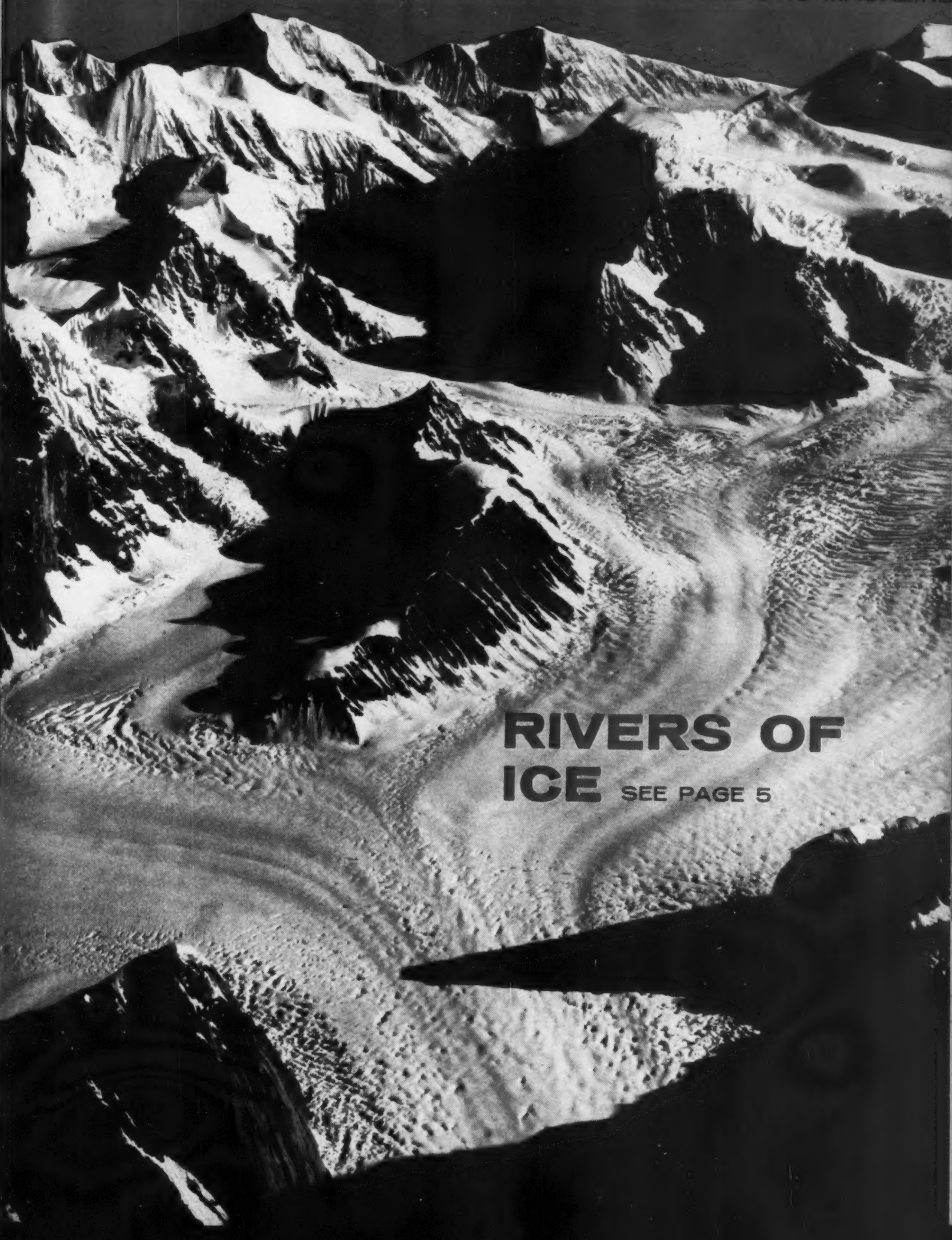

RIVERS OF ICE

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A PARALLEL WORKSHOPS

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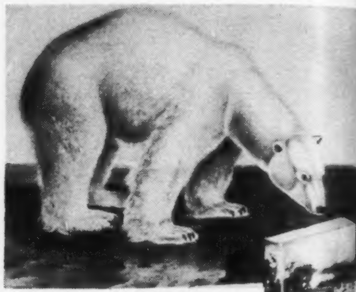

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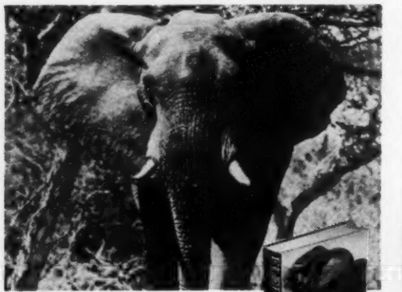

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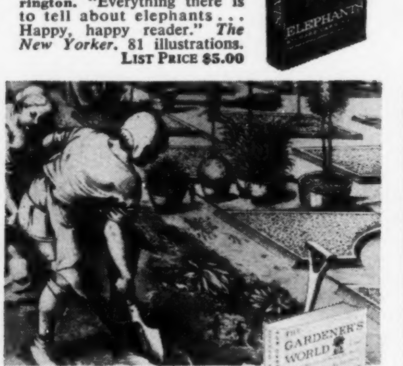

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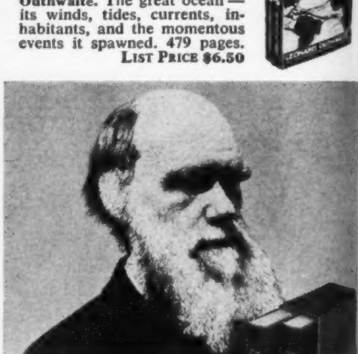

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Departments

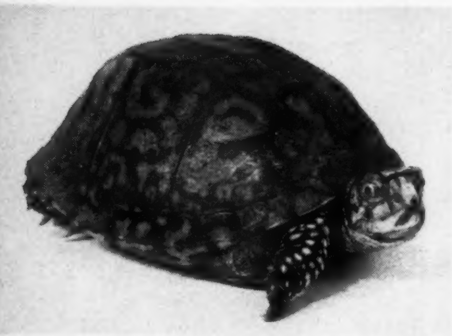
Science in Quotes

It is very easy in science to indulge in . . . "Monday morning quarterbacking" . . . to read the history of science backward. From our vantage point . . . we may say that, had such a group as the one assembled by Florey and Chain undertaken their work of 1939 in 1929, we would have had penicillin ten years earlier. Yet I find it hard to conceive of any committee . . . recommending in 1929 that this be done. Such a group . . . would have acted in terms of the contemporary climate of opinion and surely would have caused attention to be concentrated on vaccines, toxins, and antitoxins, rather than on microbial antagonism.

That is the very reason why . . . future scientific discoveries will remain unpredictable. Every scientist is a product of his environment; and his thinking . . . is limited by the scientific situation in which he lives and works.

—I. BERNARD COHEN

Letters



N. Y. Zoological Society photo

Box Tortoise above, found in Rhode Island, is at least 116 years old. Date "1844" is scratched on its lower shell.

Oldest Turtle

Dear Editor:

I especially enjoy the "Letters" section of your magazine. I have a question that I have been wondering about for a long time. How old can a turtle live to be and where do the oldest ones live?

Susan Sendrikowski
East Elmhurst, New York

Answer: Turtles live longer than any other animal that has a backbone. The Common Box Turtle, Terrapene carolina, usually lives for more than halt a century. There is evidence that some have lived for more than 123 years. One box turtle with a set of dated initials on its lower shell was discovered in New England. The dates showed it to be at least 129 years old.

A tortoise (land turtle) presented by Captain John Cook in 1777 to the king of Tongatabu in the South Pacific is still strolling around the compound built for it at that time. No one knows how old the animal was when Captain Çook made his presentation.

Cut by a Glass Sponge

Dear Editor:

I would like to know whether the glass sponge will cut human flesh?

Phillips Abbott
Natchez, Mississippi

Answer: Glass sponges grow in marine waters. Their skeletons consist of needlelike projections in an interlacing framework. If you rubbed against one you might scrape yourself but you would not actually receive a cut.

Righty or Lefty

Dear Editor:

What factors determine whether you are right-handed or left-handed? Has it anything to do with heredity? Can a person use one hand as well as the other if he is trained?

John Loop
Concordia, Kansas

Answer: The question concerning the manual preferences of individuals has never been answered satisfactorily. Some scientists believe that the preference is inherited. Others, including psychologists, believe it is the result of training. The dominance of one cerebral hemisphere over the other is also thought to give rise to right and left-handedness. It is likely that an individual's preference for a given hand is the result of many influences.

Usually, left-handed parents have left-handed children more frequently than do right-handed parents. Studies have shown that even immediately after birth, infants move one arm more than they do the other. This arm is usually the right one. As age increases, consistency in using one hand develops.

People who have equal skill in both hands are called ambidextrous. The great genius of the Renaissance, Leonardo da Vinci, could write, paint or draw equally well with either hand. The reasons for ambidexterity are not yet fully understood. It is known that the right half of your body is controlled by the left cerebral hemisphere of your brain, and vice versa. The ambidextrous person seems to have developed both hemispheres so that they operate independently.

Can you train a person to be ambidextrous? Psychologists say that very few children can develop ambidexterity. It is best to develop skills in one hand. Those who possess ambidexterity have it without training.

Do Insects See Colors?

Dear Editor:

Are insects color-blind?

Patrick Mitchell
Pasco, Washington

Answer: Scientists know very little about color vision among insects. Because we are able to perceive color, we assume that all other animals see the same multi-colored scenes we do.

Scientists have found that bees are blind to red. They live in a world of blues, yellows, and purples. However, they can see farther into the ultraviolet ranges than can human beings.

It has been found that houseflies dislike all shades of blue. Mosquitoes indicate a preference for black. In one experiment, seven men wore shirts of a different color. They were in an area heavily infested with mosquitoes. Within just half a minute, the black shirt had attracted 1499 mosquitoes as compared to only 520 counted on the white shirt.

If bees are trained to respond to a blue card and the blue card is then replaced by a gray card on which is then placed a yellow card, the bees respond to the gray as if it were blue. This also occurs in human vision, since blue and yellow are complementary colors. Gray set next to yellow appears to be blue.

Power in a Penny?

Dear Editor:

I have recently been trying to answer the following question: If a penny were dropped from the Empire State Building, would its momentum be great enough to crack the cement sidewalk below or to shatter the penny itself to pieces? I have read that a freely falling body ceases to accelerate after a certain speed. Would this be true in the case of this penny?

Julia F. Tybor
St. Cyril Academy
Danville, Pa.

Answer: The Empire State Building is about 1,500 feet tall. A penny falling from the top will have a velocity of about 330 feet per second when it hits the ground. This is less than one-fifth the speed of a rifle bullet, and hardly enough to crack the cement, or do more than dent the penny. Of course, a heavier weight traveling at this speed could do considerable damage. These figures do not take into account the friction of the air, which would slow down the penny. When the force of the air's friction equals the force of the earth's gravity on the penny, it would no longer accelerate but would continue on its trip at constant velocity. In this case, the friction of the air might reduce the penny's maximum speed to only 100 feet per second.

SECRETS OF THE BIG ICE

BY ELIOT TOZER

In laboratories provided by nature, scientists are trying to learn more about the earth

Photo by Bradford Washburn

Glacier in St. Elias range in Alaska moves down slope. Dark bands contain rock debris—moraines—worn from valley walls.

HIGH on the roof of the world there is an ice-locked laboratory, an outdoor laboratory provided by nature. Here scientists study glaciers to understand their growth and development as they slowly and silently flow down the slopes of mountains.

To most people glaciers are awesome. When they think about them at all, they see them as massive slopes of incredible beauty. To the scientist, however, glaciers are not only majestic rivers of crystal. They are an important part of the earth's environment that can be studied to learn more about the deformation, movement, and building of the earth's crust. A glacier is a self-contained physics and chemistry laboratory. Glaciologists of the Snow, Ice, and Permafrost Establishment (SIPRE) of the U. S. Army are hard at work studying the molecular structure of glaciers—in the field and in special low-temperature laboratories.

Why this intense interest in these strange rivers of ice?

Scientists have long been interested in glaciers, but in this age of airplanes and air travel over polar routes, glaciers take on a new im-

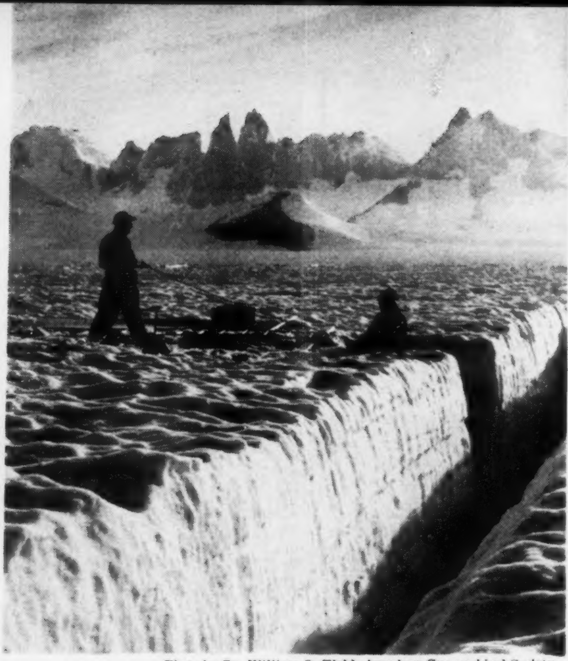


Photo by Dr. William O. Field, American Geographical Society

Scientists working on ice research project lower themselves into glacier crevasse to study inner workings and past history. This glacier is about 1000 ft. thick, moves foot a day.

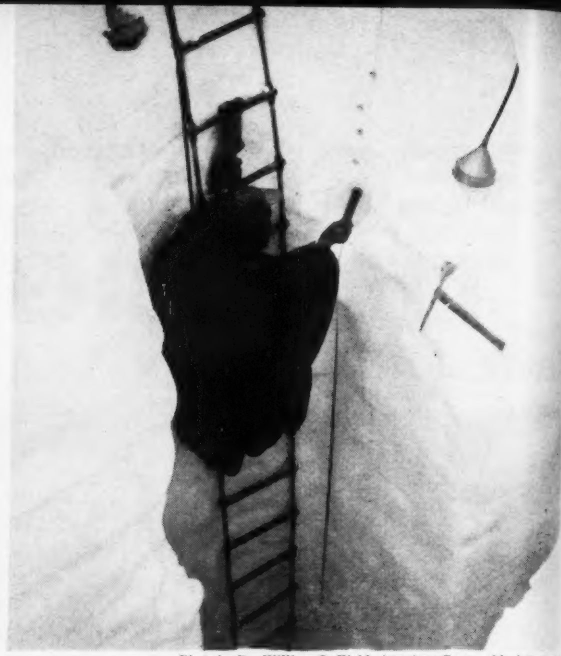


Photo by Dr. William O. Field, American Geographical Society

Scientist is coring downward into ice to learn density at various levels. Pans on sides of crevasse, called melt water pans, are used to catch melting water, measure circulation.

portance. Planes might have to land on ice and take off from ice. Research on glacier ice and its crystal structure is therefore becoming intensified. Army, Navy, and Air Force scientists now spend many months of the year melting, re-freezing, and otherwise testing polar ice.

As you might expect, glaciers form where summer heat does not completely melt winter snows, so that snow accumulates from year to year.

Glaciers on Equator

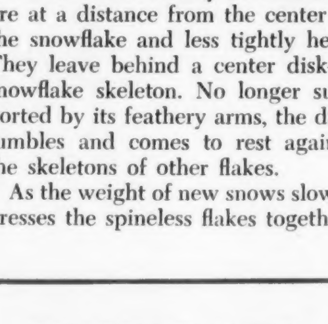
Sometimes, if there is more moisture in the southern part of a country than in the north, most of the glaciers will form in the south. Such is the case on the Alaskan coast. In 1955 a new glacier was found on Mt. Wheeler in Nevada. And, believe it or not, there are several small glaciers on the peaks of the 16,000-foot-high Nassau range in Dutch New Guinea, just four degrees south of the Equator.

Glaciers seem to be static masses of ice, but actually they undergo continual change. They begin as snow, usually in the wind shadow and sun shadow of a high peak, change to "firn," a coarse granular substance, then ice—all the while flowing down the mountain to the warm valley, where they melt away.

When snow first swells down onto the lee side of a high mountain, it is light and fluffy. Partly by evaporation, but mostly by sublimation (ice, a solid, changes to water vapor without passing through the intermediate liquid stage), the points of the six-sided snowflakes evaporate and drift away. The molecules at the points sublimate more readily because they are at a distance from the center of the snowflake and less tightly held. They leave behind a center disk—a snowflake skeleton. No longer supported by its feathery arms, the disk tumbles and comes to rest against the skeletons of other flakes.

As the weight of new snows slowly presses the spineless flakes together, pressure may build to thousands of tons. Under this pressure, the flakes begin their long change to crystals of true glacier ice.

Scientists have found that it may take hundreds of years for this change to be completed. Throughout the change, the crystals maintain the basic six-sided shape of the snowflake. At the bottom of the glacier, where the pressure may be thousands of tons per square inch, the crystals may grow several feet long. True glacier ice, found 100 to 300 feet below the snow surface, is incredibly hard. It is formed in the same way that sedimentary rock is



Science World graphic

Diagram illustrates movement of valley glacier. Stakes driven in straight row across top of glacier in short time show a curve downstream. Pegs placed on side of glacier show that top of ice river moves faster than does the bottom.

Geologist sights through transit, signals partner. Stakes placed at intervals in straight line measure speed, direction of ice flow, as stakes move out of line.

American Geographical Society

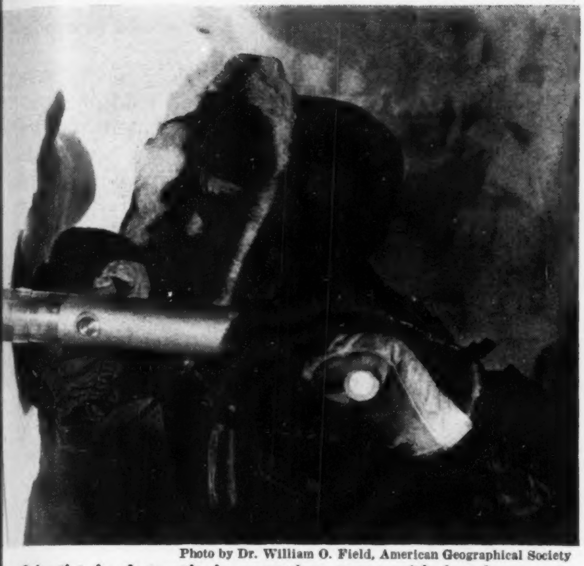


Photo by Dr. William O. Field, American Geographical Society

Scientist in Antarctic is removing snow with hand corer in shallow snow pit to get measurement of snow density. On wall of pit is meter stick showing depth of snow sample.

U. S. Navy photo

These scientists are weighing a snow sample after it is removed from coring auger. Snow is being weighed to find density. As pressure compacts snow, density increases.

formed. Indeed, glaciologists call true glacier ice "rock."

How do water molecules attain such hardness? To answer this question we must consider the ways in which atoms combine to form molecules.

Every atom has a nucleus of one or more protons, positively charged, surrounded by electrons that are arranged in shells or layers, like the layers of an onion. The shell nearest the nucleus, the first shell, has room for two electrons. In the second and third shells there is room for eight electrons each. There are two ways in which atoms join to form molecules. The first, called an ionic bond, occurs when a small number of electrons are transferred from the outer shell of one atom to the outer shell of another atom. Such a molecule is held together by electrical attraction.

How Crystals Are Held

Water is a good example of another way in which atoms are held together. This way is called covalent bonding, in which shells are completed by *sharing* electrons rather than by transfer. Thus when two hydrogen atoms form water by sharing their electrons with an oxygen atom (thus filling the outermost shells of all three atoms), they tend to take the triangular shape which is the basic form of the six-sided snow crystal.

But what locks these molecules so tightly together? Hydrogen is the key.

The hydrogen atom has one electron. When a hydrogen atom is joined to an oxygen atom by sharing, the electron of the hydrogen atom cannot circle rapidly around the proton nucleus to cancel its charge. It is a little easier to think of this by imagining the electron held close to the oxygen side. You see how this

Intensity of radiation from sun is being measured in Antarctic. Instrument is pointed toward sun. Amount of intensity is shown on meter in the foreground.

American Geographical Society

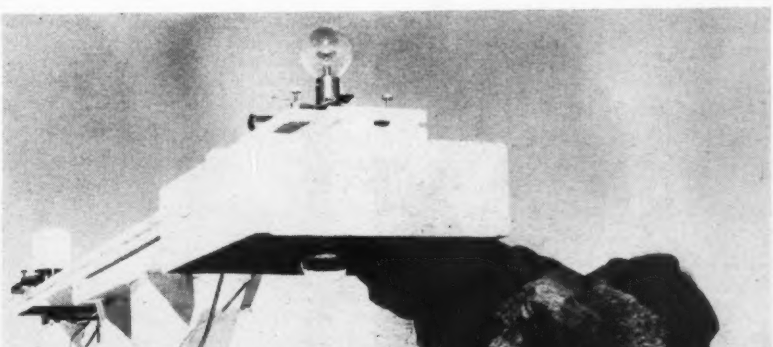


Photo by Dr. William O. Field, American Geographical Society

Instrument measures radiation reflected from snow—90% is reflected in Antarctic.

exposes a little bit of the positive charge of the nucleus. This, according to current scientific theory, is just what happens. The small, leftover positive charge acts as a kind of "hook" which scientists call the *hydrogen bond*. By means of this hook a molecule of water can join with others in combinations of molecules.

At the low temperature and high pressure found in glaciers, these combinations of water molecules, held together by the hydrogen bond, take the shape of six-sided crystals. At the end of about a year, the fluffy snowflakes have changed into coarse crystals about one mm. in diameter. Skiers call such crystals corn snow. Scientists call them *firn*. They are the basic material for glacier building.

The final change—from firn to glacier ice—may take 20 to 300 years. The time depends upon the temperature of the glacier mass and the speed with which snow accumulates on the surface to build up the pressure below.

As the pressure builds up, strange things begin to happen. The tiny crystals of firn, subjected to greater and greater pressure from above, pack tightly together the way corn flakes do when you shake the box. Most of the air trapped between the crystals is driven out—but not all. Occasionally glaciologists studying firn have been startled by the hiss of escaping air as it whistles to the surface.

Eventually the crystals become so tightly packed that the remaining air is trapped as bubbles under tremendous pressure. Brought to the surface in a coring drill (*see photo*), ice containing trapped air sometimes explodes in the glaciologist's hands.

Only when all the air has escaped from ice does it become true glacier ice: hard, glassy, and composed entirely of ice crystals, some large, some small, but all packed tightly together by the weight of the snow above. The temperature of glacier ice reflects the average annual air temperature. It ranges from less than 50 degrees F. in Antarctica to 32 degrees F. in the glaciers of the Alps and the Rockies, which lie in the temperate region.

Relentless River

Now, drawn by the pull of gravity, the dense, glassy ice begins its long, slow journey, gouging out huge boulders and uprooting trees. Like a river, a mountain glacier flows faster in the middle than it does on either side. And, like a river, it flows relentlessly around those obstacles it cannot move.

If you're wondering how such a dense and frigid mass can actually flow, you're in good company. Some glaciologists are not yet thoroughly convinced that glacier ice can flow, continuously reshaping itself without breaking. Experts who believe glacier ice is plastic have a theory to justify their belief.

Like many other scientific theories, this was supported by observing a similarity in an unrelated phenomenon.

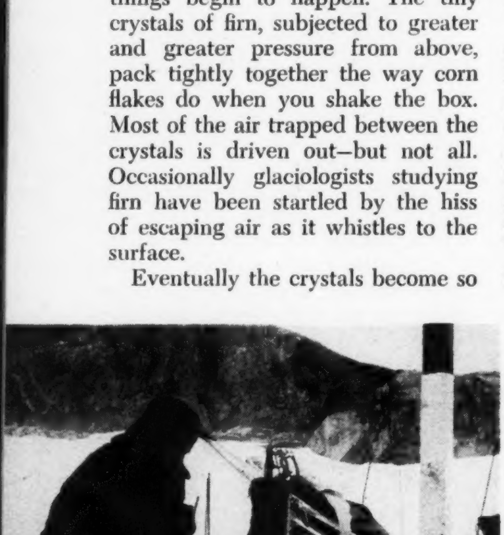
Zinc crystals deform under pressure. Although each kind of crystal has its own unique pattern, the scientists thought that the same principle of deformation might be at work in both zinc and ice. Each crystal of ice might be thought of as a stack of dinner plates locked together by the hydrogen bond.

What happens if you push gently against a stack of dinner plates? The stack will curve outward, away from the pressure. It is believed that this is what happens to ice crystals under pressure. Ukichiro Nakaya, a physicist at SIPRE, calls the sliding plates the "gliding layer."

Although the crystal has been wrenched out of shape by the relentless pressure from above, it reshapes itself. Glaciologists are not sure they know how this happens.

There is still another process by which the dense and sluggish mass of ice changes its shape and internal structure so that it can flow. If you've ever packed a snowball or gone ice skating, you've seen this principle—called regelation—at work.

When you go skating, your weight, concentrated on the small area of the skate blade, produces pressure which lowers the melting point of ice. The melted ice acts as a lubricant over which the blade glides with a minimum of friction. Regelation enables you to pack a snowball too. The pressure of your hands melts some of the snow and it re-



American Geographical Society

Lead oxide dye is being sprinkled on late summer snow surface. Next year dye will give clue to amount of winter snowfall.

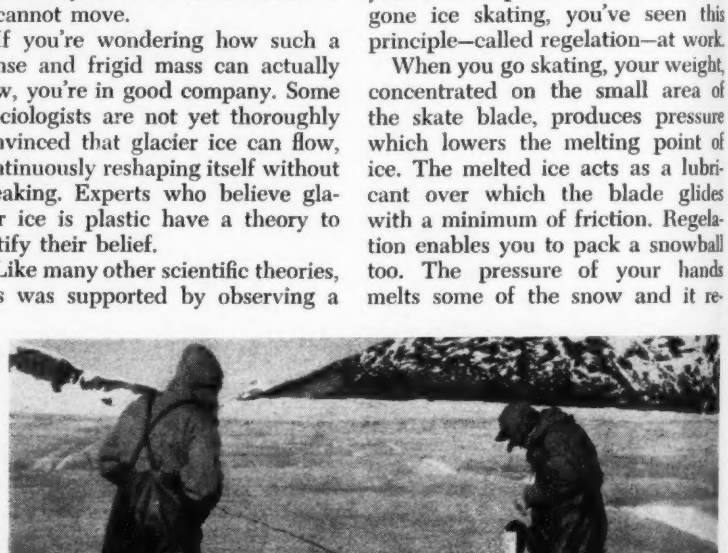


Photo by Dr. William O. Field, American Geographical Society

These scientists are measuring ice thickness on the Taku Glacier in Alaska. Dynamite charge is set off and seismograph measures time it takes for sound waves to reach bedrock and return. At this point glacier measured 1300 feet.

freezes when the pressure is released.

The extreme pressures on glacier ice cause the same thing to happen. Ice melts and flows around projecting rocks or through narrow twisting valleys. As soon as the pressure is released, the ice refreezes, forming new crystals. This continual melting, freezing, and remelting of ice allows the glacier to move slowly down and around a turn in a valley. A glacier can even have "waves." A sudden heavy fall of snow at the source—or an avalanche triggered by an earthquake, for example—may exert a pressure that propagates a wave down the glacier. Ice particles within such waves have been clocked traveling at three times the speed of the main river of ice.

As glacial ice moves down a mountainside, it leaves a record of its passage which survives thousands of years. Pieces of rock, pushed and dragged along, give the glacier the effect of a huge rasp. These rocks, boulders, sand, and gravel are called *moraine*. Some of the moraine is pushed ahead by the glacier, some is picked up and borne along the sides, and some is dragged along underneath the ice. In the process, these become tools of glacial erosion. Marked and polished as they are dragged along, they also leave scratches in the bedrock. These survive the retreating glacier, leaving a permanent record of part of the earth's story, to be "read" by future generations.

So, through deformation and regelation, the glacier continually moves forward, shifting and shearing, forming and reforming, until it spills out into the sea or grinds to a slushy halt in the warm valley.

Air Strip on Ice Floe

Detailed study of ice crystals has suggested an answer to a major military problem: How do you construct an air strip on an ice floe in the Arctic?

Crystals of metal, as we know, can be made stronger by introducing alloy metals. In an alloy, a combination of two or more metals, one of the metals usually has smaller crystals than the other. The smaller crystals fit in between the spaces of the larger crystals and act as a brace, thus producing a new type of metal stronger than either of its

American Geographical Society

Botanist makes periodic checks on plant life in area where glacier has receded. He uses rectangle to chart types of plant life and their extent, to determine annual speed of revegetation and kind of vegetation that is returning to the area.

constituents. Air Force scientists have found that ice can be alloyed in the same manner, and made stronger by introducing such substances as clay. Utilizing this phenomenon, they hope to produce ice that can sustain much more weight than pure ice.

Glaciers, of course, are not noted for their speed. Several factors influence their movement: the surface gradient of the glacier or slope of the valley, the thickness of the ice, the air temperature. To these we can add the smoothness of the surface over which the ice flows, the amount of water in the ice, and, finally, the amount of debris—boulders, rocks, sand, and gravel—which makes the glacier heavier.

Some glaciers in Switzerland move one to three feet a day. A famous European glacier carried the bodies of three guides, who perished in a climbing accident, a distance of 8,000 feet in 41 years, an average of 200 feet a year. The Muir glacier in Alaska has been measured as moving about seven feet a day. There are some "fast" glaciers. Glaciers that flow into the fiords of Greenland have been observed to travel more than 100 feet a day.

The greatest glaciers of all are the continental glaciers—the Antarctic and Greenland ice caps. The Greenland ice cap stretches more than 1,500 miles from north to south, and sprawls about 600 miles at its greatest breadth—an area about three times as large as Texas. The maximum thickness of the ice is about two miles—more than 10,000 feet—and it fills a huge basin surrounded by coastal mountains. Constantly flowing toward the edge of the basin, it either spills through valleys or empties directly into the sea, where massive pieces break off to become icebergs.

Nearly all of Antarctica is covered by an ice cap one and one half times as large as the United States. The ice shelf occupying half the Ross Sea is simply a floating portion of the ice cap. Scientists are at work gauging the thickness of the ice cap by setting off a small charge of dynamite and measuring the time it takes for the sound waves to travel through the ice to bedrock surface and back.

Geologists regard ice caps, which now cover almost 10 per cent of the earth's land surface, as survivors of the ice age which once covered nearly 30 per cent of the earth's land surface. This had its greatest advance about 18,000 years ago.

Another Ice Age?

Will the earth have another ice age, burying its great cities under tons of glassy "rock"? We do not know. We know only that evidence accumulated by scientists over the past century indicates that most of the world's glaciers have been retreating, melting away.

A total of about one per cent of the earth's water supply is locked up as ice—at least 5,000,000 cubic miles, says Dr. William O. Field, head of the Department of Exploration and Field Research, of the American Geographical Society. Most of it is in the huge ice cap at Antarctica, and a good part of the remainder is in the cap that buries Greenland. "If it were all to melt," says Dr. Field, "the level of the oceans would rise about 200 feet."

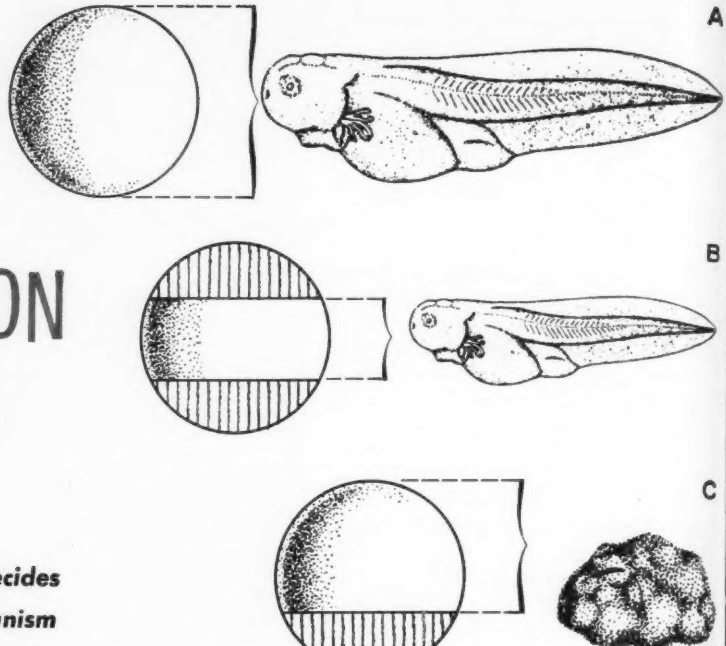
The great coastal cities of the world may be "drowned" before they are crushed and swept away by continents of ice.

CELL DIFFERENTIATION

Blueprint of a Problem

By RICHARD BRANDT

Scientists are trying to learn what decides a cell's eventual function in the organism



Science World graphic

Frog egg cell is split into north and south poles, equator. Equatorial cells alone can result in complete organism. North cells with equatorial cells upset balance.

TWO cells are growing in the embryo. They seem to be identical in appearance and similar in behavior. Yet one eventually will become a skin cell, the other a nerve cell. What is it that decides their eventual function in the organism? This is a basic question scientists are striving to answer.

Let us consider the development of the embryo as taking place in two stages: (1) the stage we might call the pre-embryo, and (2) the embryo. But first consider the egg itself. To illustrate the problem, let us divide an egg cell into hemispheres. One half, which we will call the "north pole," may contain a greater amount of a particular enzyme than does the "south pole" half. If this is so, then the "south pole" may contain a greater proportion of other substances. *Proportions* may vary, but throughout the egg cell the substances are the same.

This difference has also been found in the dividing cells of the *pre-embryo*. This is the stage of development immediately after fertilization—but before the cells begin to carry out their specific functions. Dr. Sven Horstadius, a Swedish embryologist, provided experimental evidence of this difference. He dissected the pre-embryo of the sea urchin into three groups of cells. He designated these groups as "north pole group," "south pole group," and "equatorial group." The equatorial group matured into a complete sea urchin. The north and south pole groups never developed fully.

This experiment raised a question: Does the equatorial group of cells contain ALL the substances needed for the development of a sea urchin, while the pole groups do not?

Polar Balance

This question suggested one of those beautiful experiments in science—beautiful because it can be simple in design but supremely accurate in result. Horstadius placed the dissected pole groups in contact with each other. A normal sea urchin developed.

Now Horstadius knew that the north and south poles would produce a complete sea urchin, the equatorial cells alone would produce one, while the north or south poles by themselves would not. Although the true nature of what it is that causes cell differentiation remained a mystery, its location was now less mysterious.

The sea urchin, however, is a relatively simply animal. Dr. Mabel Paterson of Vassar College recently performed an experiment involving polar balance with a more complex animal—the frog. She dissected a frog pre-embryo and demonstrated that, as in the sea urchin, the equatorial cells can give rise to a complete organism. She also showed that the north polar cells, in contact with only the equatorial cells, caused development to cease. Apparently, the north polar cells upset the balance.

The experiments of Horstadius and Paterson suggest that when polar balance is present, a group of cells removed from the pre-embryo can develop into a full organism. This suggests a theory that each cell of the pre-embryo follows a "blueprint." Another question then presents itself: How does each of the differentiating cells know which "blueprint" to follow?

The nucleus of the cell is believed to hold the key. The key is

thought to be the nucleic acids, found in the nuclear matter of the cell. These acids are believed to be the "blueprints" for cell differentiation.

During the division of the fertilized egg cell, a complete file of blueprints is distributed to each daughter cell. The daughter cells, in turn, distribute an identical file to each of their daughters. During differentiation, the cells take on specialized functions, as though each were following one print selected from the complete file. Thus cells identical in appearance and similar in function in the pre-embryo become as different in appearance and function as skin and bone.

If cells located in the same embryo receive the same file of blueprints, they should all be identical. What enables them to differentiate?

Two theories have been suggested by researchers. One theory holds that cells receive their *individual blueprints* from other cells. The other theory suggests that the cells receive only *information* from other cells which, in effect, tells them how to use blueprints they already have on file. Let us look at the experimental evidence presented for these theories.

The German biologist Hans Spemann transplanted a bit of tissue—tissue that normally would change into a backbone—into a pre-embryonic region which would normally become the belly. The bit of "backbone tissue" continued its development into backbone tissue and even the "belly cells" surrounding the transplant also became "backbone tissue."

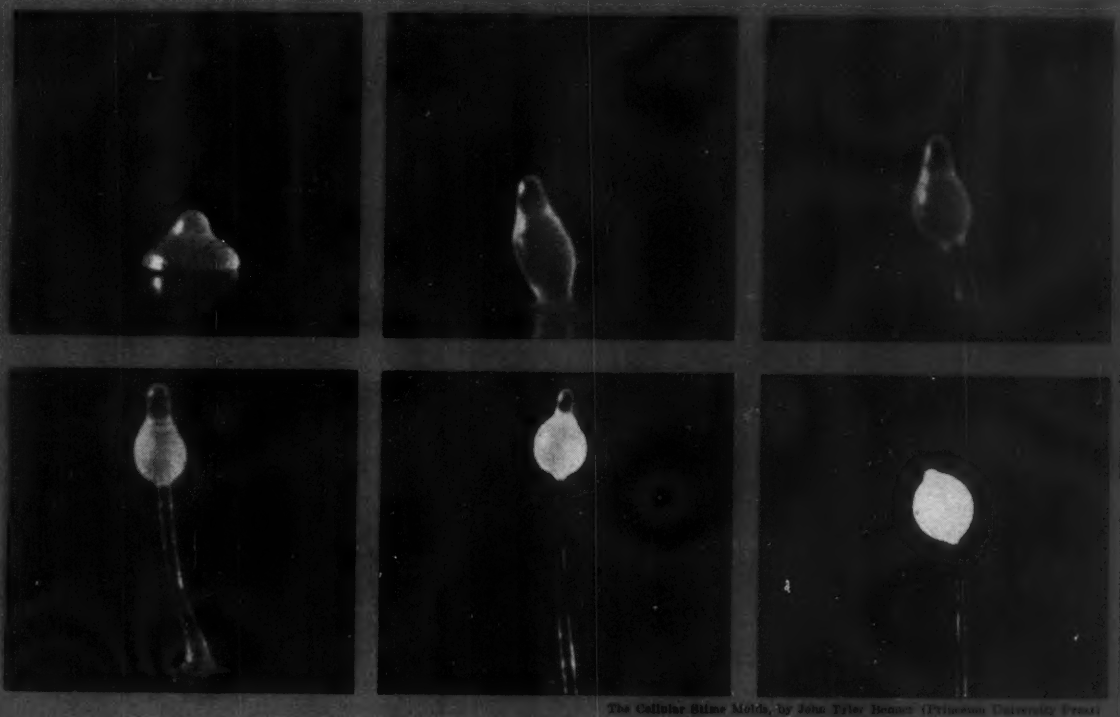
The "Blueprint" Theory

What enabled the "belly tissue" surrounding the transplant to become "backbone tissue"? Did the cells receive new blueprints? If so, from where? They may have received them from the transplanted bit of backbone tissue, or they may have received *information* from the transplant which caused them to revise an existing blueprint.

Dr. S. Meryl Rose, professor of zoology at the University of Illinois, has suggested a hypothesis to explain the phenomenon of cell behavior during differentiation.

Imagine that each cell in a developing embryo has a complete cabinet of blueprints. Now suppose that one of the cells begins to use a specific set of blueprints, say, those filed under A. These blueprints direct the cell to perform certain chemical activities. Now suppose that the products of these chemical activities enter neighboring cells, preventing them from using *their* blueprints filed under A. In this case the products act as "inhibitors." The cells receiving such products then follow *another* set of blueprints, possibly those filed under B. To carry the analogy a step farther, the cells using the blueprints filed under B will influence still other cells, causing them to differentiate by following blueprints filed under C. This would go on until all the parts of an organism were brought into being.

Obviously, no scientist hopes to



The Cellular Slime Molds, by John Tyler Bonner (Princeton University Press)

[Sl]ime molds in amoeba-like stage stream together and form [m]any-celled structure. Spore case is borne on stalk. Series photos taken with 16 mm time-lapse camera. Each photo represents time interval of approximately one and one half hours.

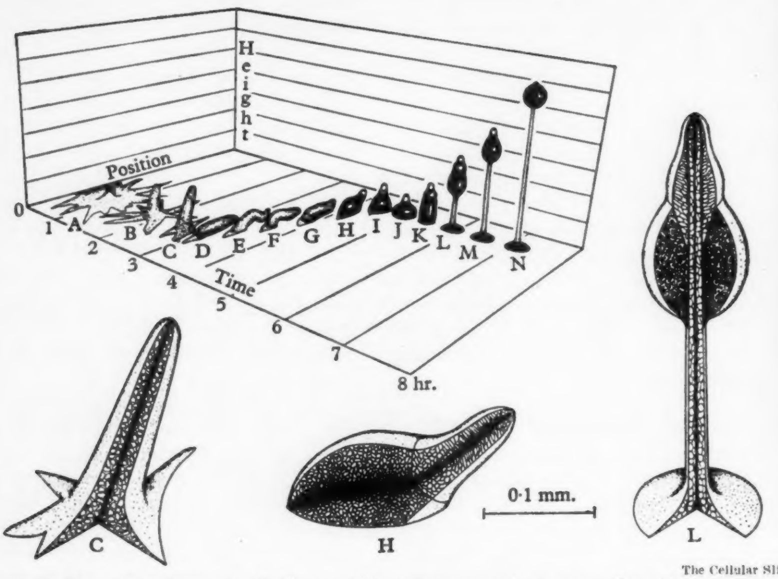
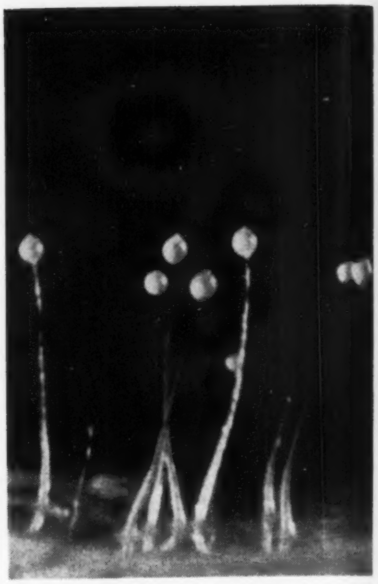


Chart shows development of slime mold. A-C represents aggregation; D-H, migration; I-N, culmination. Semi-diagrammatic drawings show cell structures at stages.



The Cellular Slime Molds, by John Tyler Bonner (Princeton University Press)

Mature fruiting body of slime mold. Micro-tessar 24 mm lens was used.

find blueprints and filing cabinets in a cell. Scientists are looking for something that may act like blueprints and filing systems, but has been doing so long before mankind knew anything about blueprints and filing systems.

To continue the analogy, in this theory some of the products of a cell's chemical activity are "fed back" to other cells to control the organism's development. This theory is therefore named the Feedback Theory of Differentiation. Scientists now suspect that minute quantities of a cell's products may inhibit a variety of chemical reactions.

At the University of Illinois, scientists sought to find the inhibitors for specific organs. They cultivated frogs' eggs with blood, or bits of adult frog brain, or bits of heart.

In the eggs cultivated with brain tissue, many embryos failed to develop. In others, no brain formed. In still others, the brain developed late or abnormally. In some eggs cultured with heart tissue, a heart failed to develop. Some eggs growing in diluted blood did not produce blood at the normal time.

Experiments with toads, chicks, and various worms all indicate that if developing eggs are grown in a culture of adult tissue, certain cells will fail to differentiate and develop their functions. It would seem that the adult tissues produce inhibiting substances.

As Dr. S. Meryl Rose puts it, "like normally inhibits potential like." The next step is to find out why particular organs develop in particular places.

Dr. John T. Bonner, of Princeton University, also is searching for the answer to how cells differentiate. He is seeking clues by studying slime molds. These are organisms found in the soil. At one stage in their existence they resemble amoebae, taking in food as separate individuals. At a later stage they stream together and form a many-celled structure which crawls about as a bullet-shaped slug. The slime mold then has a distinct front end and hind end and leaves a trail of slime as it moves—from which it gets its name.

Compete for Position

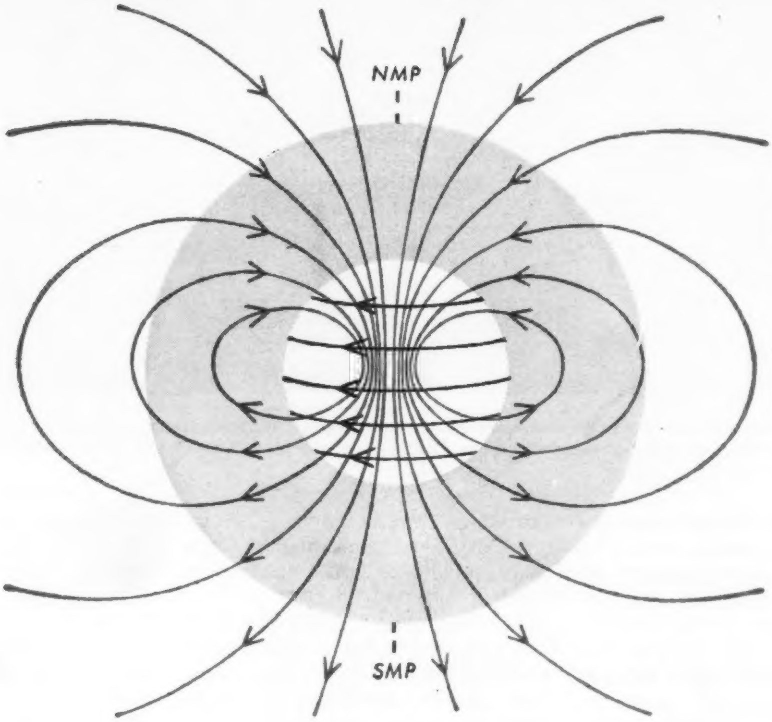
Eventually the slime mold becomes a mold-like structure with a spore case borne on a stalk—the hind cells becoming spores, and the front cells moving together to make up a tapering stalk.

The sorting out process which leads certain of the slime-mold cells to become stalk cells and others to become spores is similar to cell differentiation in embryonic chick or frog tissue. Slime molds, however, have an advantage over embryonic animals to the scientist—the sorting out process may be observed without mutilating the animal. Furthermore, the organism itself is simple.

Now, how does this regular and controlled cell differentiation take place in the slime mold? Dr. Bonner suggests that individual cells compete for certain positions during the very early embryonic stages.

In one experiment, during the slug stage of a slime mold's development, grafts were made. The cells from the front end, transplanted to the back end of a slug, moved to the front end of the "new" slug. *These grafts indicated that slime-mold cells have a definite "preference" as to location.*

All the experiments we have described were designed by scientists to answer the question of how cells differentiate. Each experiment brought them a deeper understanding of the process. The combined sciences of embryology, genetics, microbiology, biophysics, and biochemistry are being used to study the problem. Our understanding is far from complete, but the cross-fertilization of these sciences may provide signposts pointing toward the answer.



Earth's magnetism may be caused by electric currents flowing in liquid core. Core moves inside Earth like dynamo generating current.

THE MIGHTIEST MAGNET

A "dynamo" deep in the core of the Earth makes our globe a magnet

By MICHAEL DADIN

ON the Sunday afternoon of Feb. 9, 1958, a scientist on the staff of the Sacramento Peak Observatory in Sunspot, New Mexico, recorded a flare on the surface of the sun which was to have violent effects on the whole world—within a few days.

At that time he had been observing the sun, keeping a sharp eye on a growing cluster of sunspots covering some three billion square miles of the sun's surface. It was one of the ten largest sunspot groups to have appeared in the 80 years since sunspots have been measured. Such clusters are often followed by brilliant solar flares, and he anticipated an unusual flareup.

The flare, when it appeared that day, was one of the largest ever recorded. It grew and shone with fantastic brightness for about two hours, then disappeared. Realizing such flare-ups often are followed by a magnetic storm on the Earth which disrupts electrical and electronic equipment, he immediately telephoned the Central Radio Propagation Service of the Bureau of Standards. This agency forecasts impending magnetic disturbances to steamship companies and airlines. But the staff of the propagation service did not believe these solar flares would cause a magnetic storm. No warning was issued. Twenty-eight hours later began one of the greatest magnetic storms ever to hit the Earth.

The first effects of the storm were not felt by man but by instruments—magnetographs which trace on paper

The scientist using the magnetometer below is measuring the angle of dip, or inclination, in the Earth's magnetic field—a precise and difficult job. Cloth tent is used to protect instruments because cloth does not disturb the Earth's magnetism.

National Academy of Sciences photo

Aero Service Corp. photos

Airborne magnetometer probes gold fields of South Africa for buried mineral wealth by making magnetic maps. Bomb-shaped magnetometer is towed at end of 100-ft. cable to avoid plane's magnetic field. Instrument maps large areas.

changes in the direction and strength of the Earth's magnetic field. The telltale pen on magnetographs in magnetic observatories all over the world suddenly sprang into activity. At the U.S. Coast and Geodetic Station at Fredericksburg, Va., the pen on the magnetograph suddenly leaped 500 gammas (a magnetic measurement), indicating twice the normal strength of the Earth's magnetic field. At an observatory in Fairbanks, Alaska, the pen went right off the page, suggesting an intensity of several thousand gammas. Within the next minute all radio communications between the United States and Europe vanished into silence.

Effect of Solar Flares

At the moment the magnetograph pen leaped off the page, huge currents suddenly surged in power lines and cables in Canada and the United States. In Newfoundland, voltage in power circuits varied by as much as 300 volts. In Ontario, the current surges caused power stations to fail, plunging the Toronto area into darkness. A voltage of 2,600 volts suddenly appeared between the terminals of the transatlantic telephone cable connecting Clarenville, Newfoundland, and Oban, Scotland. The sudden leap in voltage came close to ruining the cable. Transatlantic planes lost radio contact with ground stations and had to fly on in silence.

The effect of such solar flares on the Earth's magnetic field is not yet fully understood. In the opinion of most scientists, a solar flare is some kind of cataclysmic explosion on the sun which spews enormous streams of electrically charged particles into space, sometimes in the direction of Earth.

These particles travel about 1,000 miles per second and reach the Earth about one day after the eruption has been observed, blanketing the atmosphere within a few seconds. The charged particles are drawn into flowing streams by the Earth's magnetism. They circle the Earth and act as currents moving in a great electric power line wrapped many times around the globe.

These currents create strong magnetic fields, upsetting the Earth's normal magnetism. They can cause compass needles to wander as much as seven or eight degrees from the magnetic north, and change the Earth's magnetic pull by as much as ten per cent. They also induce large currents and voltages in the electric cables on the Earth's surface. Once the stream of solar particles has swept by the Earth, currents in the atmosphere subside. Within 24 hours the magnetic balance of our planet is usually restored.

Such abrupt magnetic storms are only one of many variations which take place in the Earth's magnetic field. Most of the other variations observed by geophysicists are much slower. Although these slow variations pass unnoticed, except in geomagnetic observatories, they have given geophysicists many clues to a most baffling question: What causes the Earth's magnetism?

One of the earliest scientific papers on this subject was written in 1660 by Sir William Gilbert, Queen Elizabeth's personal physician, a meticulous experimental scientist. In Gilbert's time there were only two kinds of magnets: natural magnets or lodestones, and pieces of iron magnetized by rubbing them against lodestones. Since Gilbert had no other way of creating a magnetic field, it was only natural that he should write, in his treatise *De Magnete,* that the Earth was merely a huge bar magnet or lodestone.

Dynamo in the Earth

Today we know that this explanation is too simple. For one thing, the temperature of the Earth's interior is much too high to allow any material to retain permanent magnetism. In an extremely hot or liquid material, the molecules are in constant random motion and cannot be permanently aligned in one direction, to create a magnetic field.

Gilbert's view of the Earth as a giant lodestone is also contradicted by another fact that he had no way of knowing: north and south magnetic poles have a tendency to wander. Although the magnetic poles are generally found in the same area, their exact location varies from year to year, indicating changes in the Earth's magnetic field. Moreover, compasses placed at two different points on the Earth may not point to the same magnetic north.

These variations in the magnetic field have been a source of great confusion to navigators. They have also puzzled scientists ever since they were able to measure these var-

Aero Service Corp. photo

Inside magnetometer survey plane, recording equipment charts small variations in earth's magnetic field, picked up by sensitive magnetometer towed behind plane.

iations with magnetometers, which can measure the slightest changes in the Earth's magnetic field.

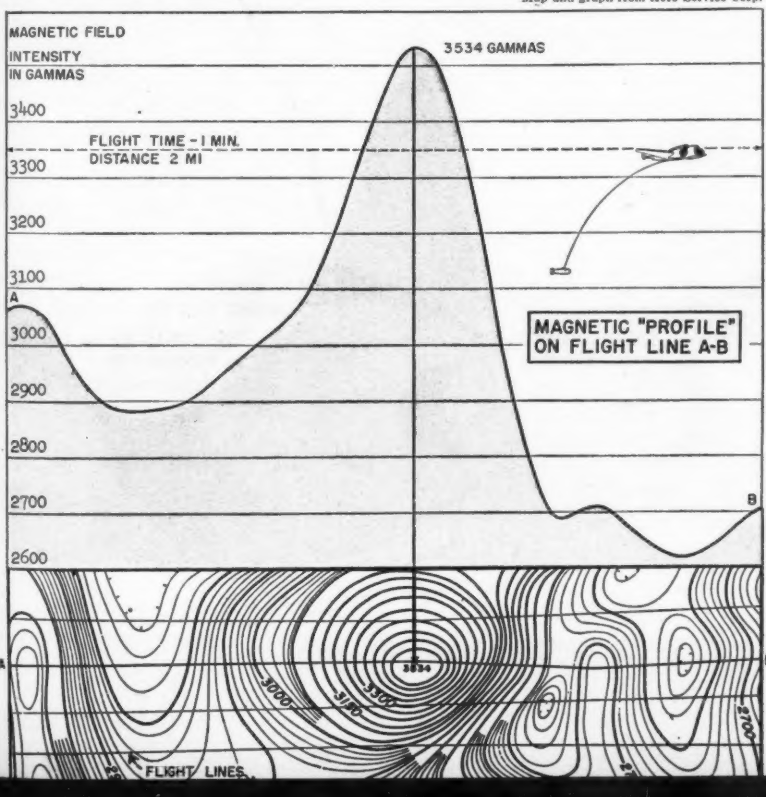
These slow variations suggest to scientists that the source of the Earth's magnetism is in motion. This motion occurs in the fluid part of the Earth's core, which is about 4,000 miles in diameter, about half of the total diameter of the globe. Scientists are reasonably sure that the material in the liquid core is some kind of molten iron-nickel alloy. Such molten material would be an efficient conductor of electricity, and fluid enough for motion to take place.

In fact, measurements of the changing magnetic field indicate that the Earth's core is moving about one hundredth of an inch per second. Although this motion seems small, in a mass as large as the core it would represent a tremendous amount of mechanical energy. Scientists theorize that this energy is converted into electric currents in the core, just as moving wires in a dynamo convert motion to electric current. Such electric currents flowing through the liquid core would then set up a magnetic field on the Earth, just as a current through a wire sets up a magnetic field around the wire.

The general shape of the Earth's magnetic field suggests that large currents in the core flow in circles nearly parallel to the Earth's Equator. This would create strong north and south magnetic poles, as would currents in a loop of wire. Additional small currents flowing at various points in the core could cause the small local variations in the direction of the magnetic field. Since the core is fluid, the motion of the material inside—and of the currents themselves—could easily vary over the years, causing slow changes in the Earth's magnetic field.

Magnetic map of ground charted by magnetometer survey plane as it flew along flight lines is shown at bottom. Numbers show magnetic intensity along curved lines, in gamma units. Top graph shows magnetic intensity along flight line A-B. Peak of intensity is seen at 3534 gammas, showing hidden iron ore deposit in Ontario, Can.

Map and graph from Aero Service Corp.

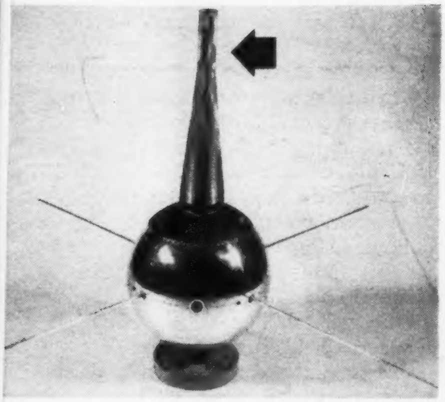


Magnetic Calendars

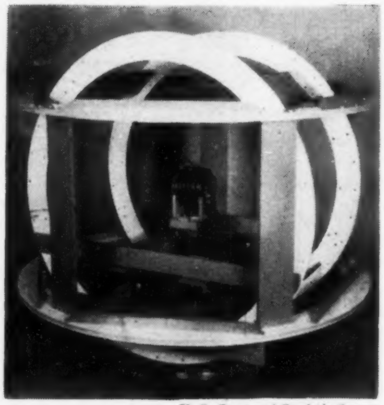
Local variations in the Earth's magnetic field have been recorded at magnetic observatories for more than 400 years. This has helped map the movement of the magnetic pole.

But it is only when we look much further back into the Earth's history that a remarkable story unfolds. It has now become possible to read the Earth's magnetic record for millions of years in the past. This is done by studying natural "compass needles," which nature has frozen into the rocks. The natural "needles" are grains of magnetic iron oxide minerals, such as hematite (Fe_2O_3) and magnetite (Fe_3O_4).

At high temperatures, particles of these materials readily line up along a weak magnetic field. When hot molten lava first pours out of a volcano *(see Science World, Jan. 13, 1960)*, its iron mineral grains become magnetized in the direction of the existing local magnetic field. As the grains quickly cool, the direction of magnetization is "frozen" into them, and can no longer be influenced by changes in the Earth's field. The grains are magnetic fossils which record the direction of the Earth's magnetic field at the time the rock was formed.



National Aeronautics and Space Administration



U. S. Coast and Geodetic Survey

Arrow in photo at left points to magnetometer at end of tube attached to Vanguard satellite. Magnetometer measured Earth's magnetic field in space, is small version of proton magnetometer at right. Small coil in center is wrapped around bottle holding water. Protons of hydrogen atoms in water act as spinning magnets, sense Earth's magnetism. Four large coils around center adjust direction of measurement.

In certain parts of the world hundreds of layers of lava may have been deposited upon each other during the Earth's formation, making a veritable calendar of magnetic history. Parts of Iceland and our own western United States have many such "calendars," some of them exposed in the walls of canyons such as the Colorado Grand Canyon.

When this frozen record of the Earth's magnetism was examined, some surprising facts were uncovered. Some 60,000,000 years ago, the north and south magnetic poles seem to have reversed places several times, and at other times they wandered around the geographic poles.

The study of magnetic rock records has been extended to man-made "rocks," or bricks, by a husband and wife team of French physicists, Drs. E. and O. Thellier. By studying Roman bricks from the year 200 B.C., they concluded that the Earth's magnetic field may have weakened as much as 65 per cent in the last 2,000 years. Because bricks contain small amounts of iron, they were permanently magnetized by the Earth's magnetic field at the time they were fired.

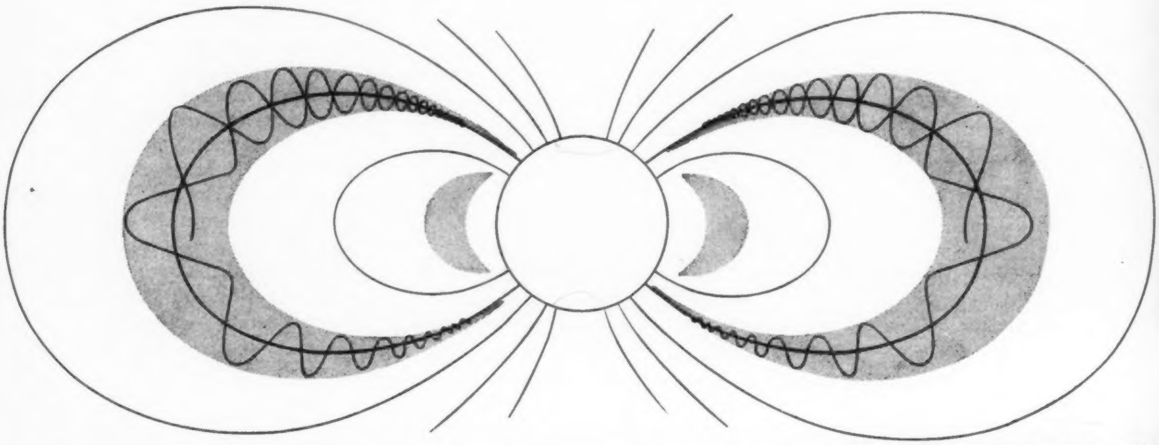
In these experiments, the French scientists first measured the intensity of the magnetization. Then they heated the samples, which erased their ancient magnetic records, and allowed them to cool and be remagnetized in the Earth's present magnetic field. By comparing the intensity of magnetization before and after heating, they deduced that the Earth's magnetic field must have been considerably stronger when the bricks were originally fired. However, this effect of "frozen-in-rock" magnetism is a delicate one, and involves many unknown factors. Scientists are still disagreeing on the interpretation of these experiments.

Just as rocks have provided us with a record of the Earth's magnetism, the Earth's magnetism is providing us with clues to buried mineral treasure. Different mineral or oil deposits cause different variations in the Earth's magnetic field. By measuring the field directly over the deposit, geophysicists can accurately predict the nature of the Earth under their magnetic measuring instruments.

This method requires no drilling for samples, and the geologist does not even have to set foot on the ground he is prospecting—the instruments can be mounted in an airplane, and all the measurements made from the air. In this way, inaccessible jungles and mountain peaks —as well as the remote Antarctic continent—can be mapped for mineral wealth.

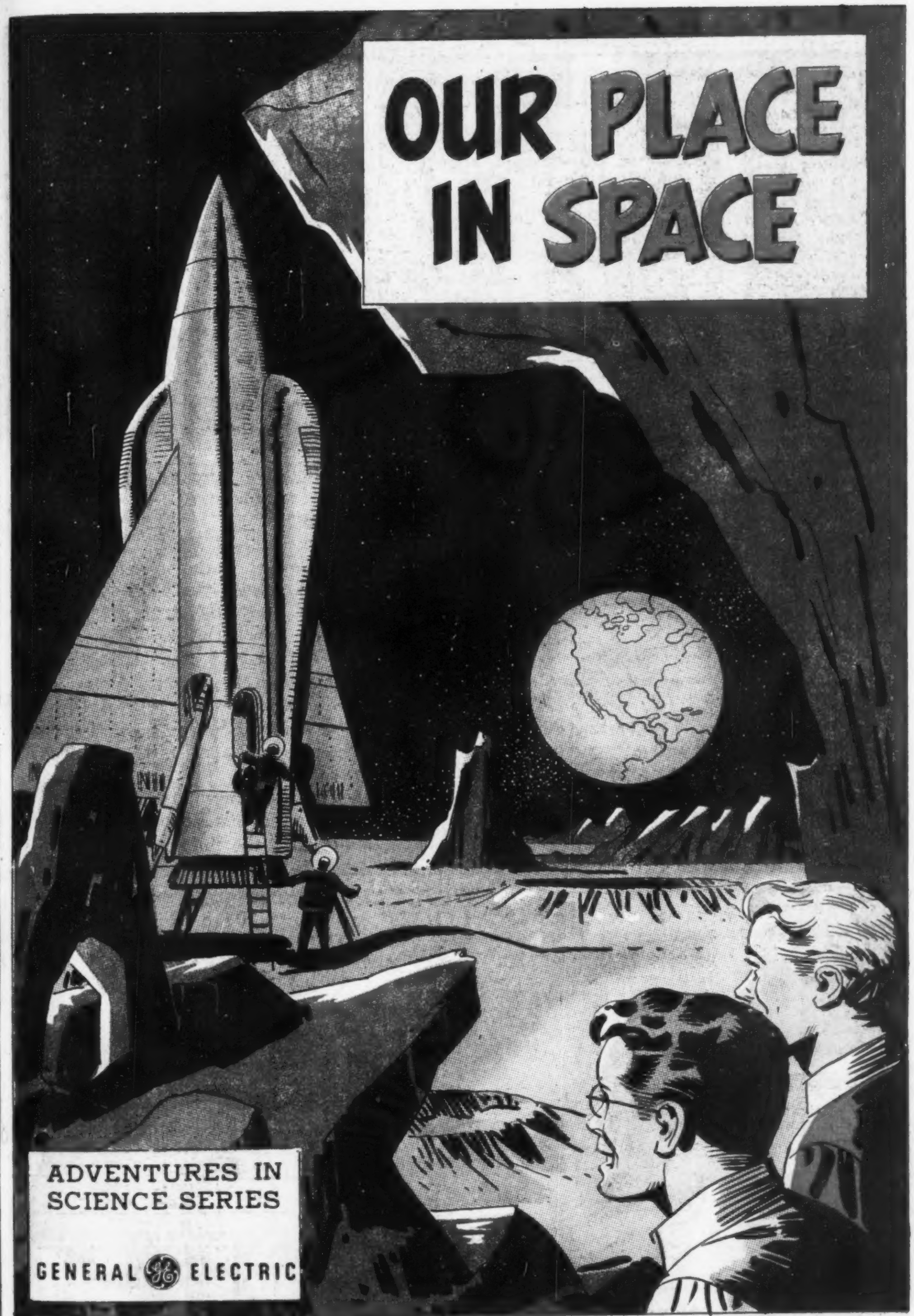
In order for the magnetometer to escape the magnetic effects of the airplane, the instrument must be suspended outside the craft, in a bomb-shaped wooden container called a "bird." The bird "flies" underneath the plane, attached to it by a hundred-foot cable.

(Continued on page 47)



Adapted from Lockheed Missile/Space Div. graphic

Deadly Van Allen radiation belt surrounding Earth is created by high-speed particles trapped in Earth's magnetic field. Particles spiral from North to South along Earth's magnetic lines of force, which determine shape of the radiation belt.



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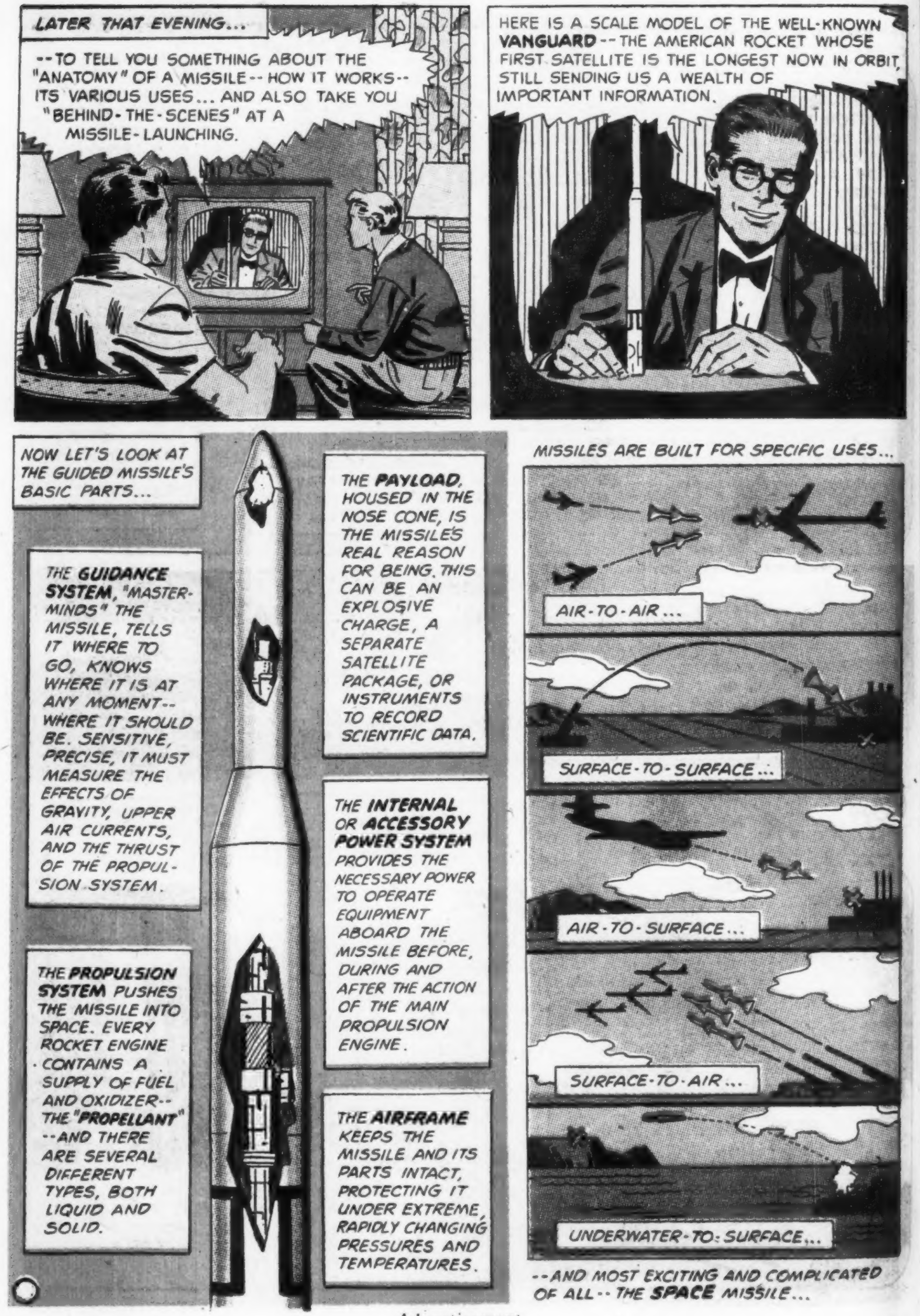

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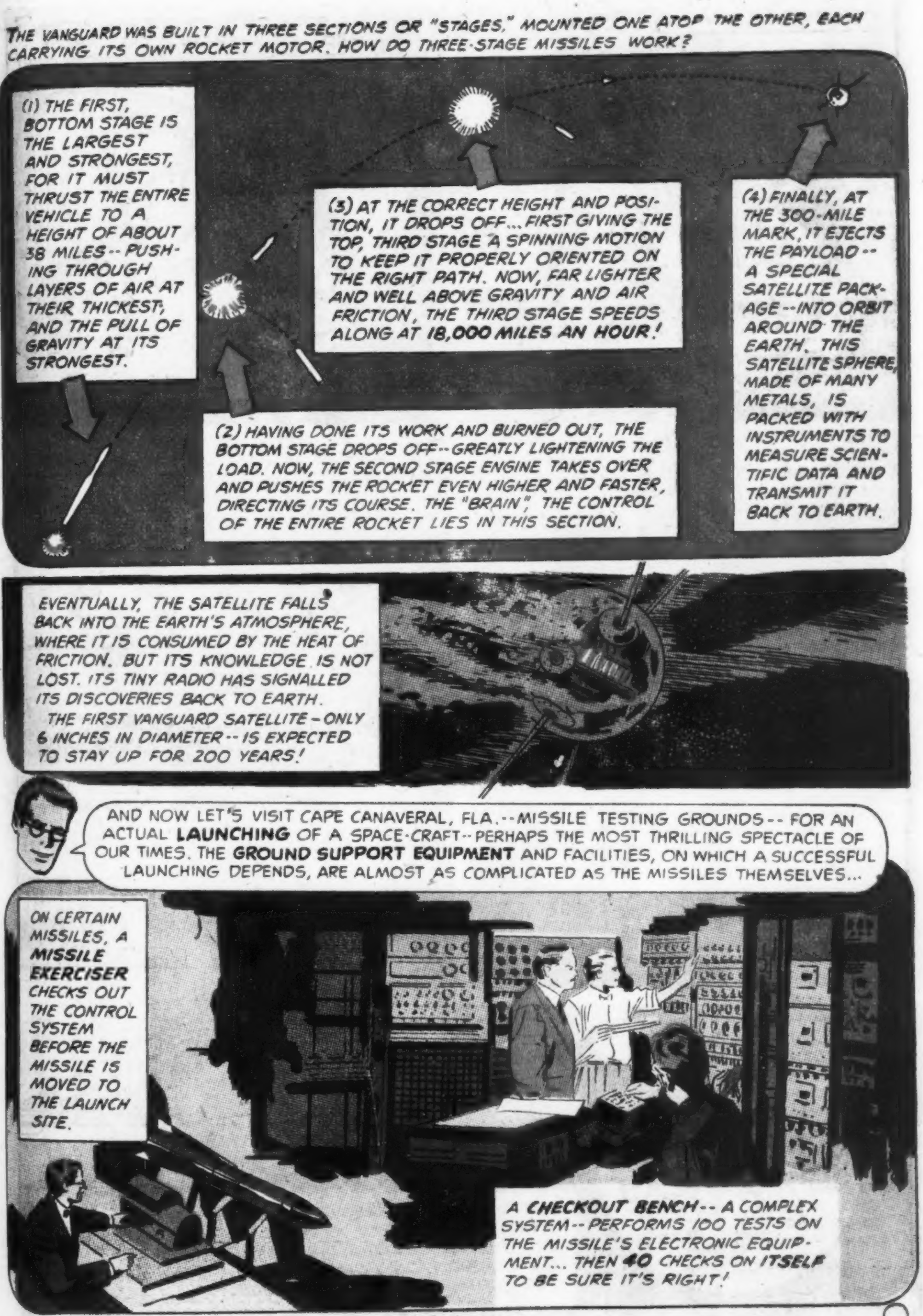

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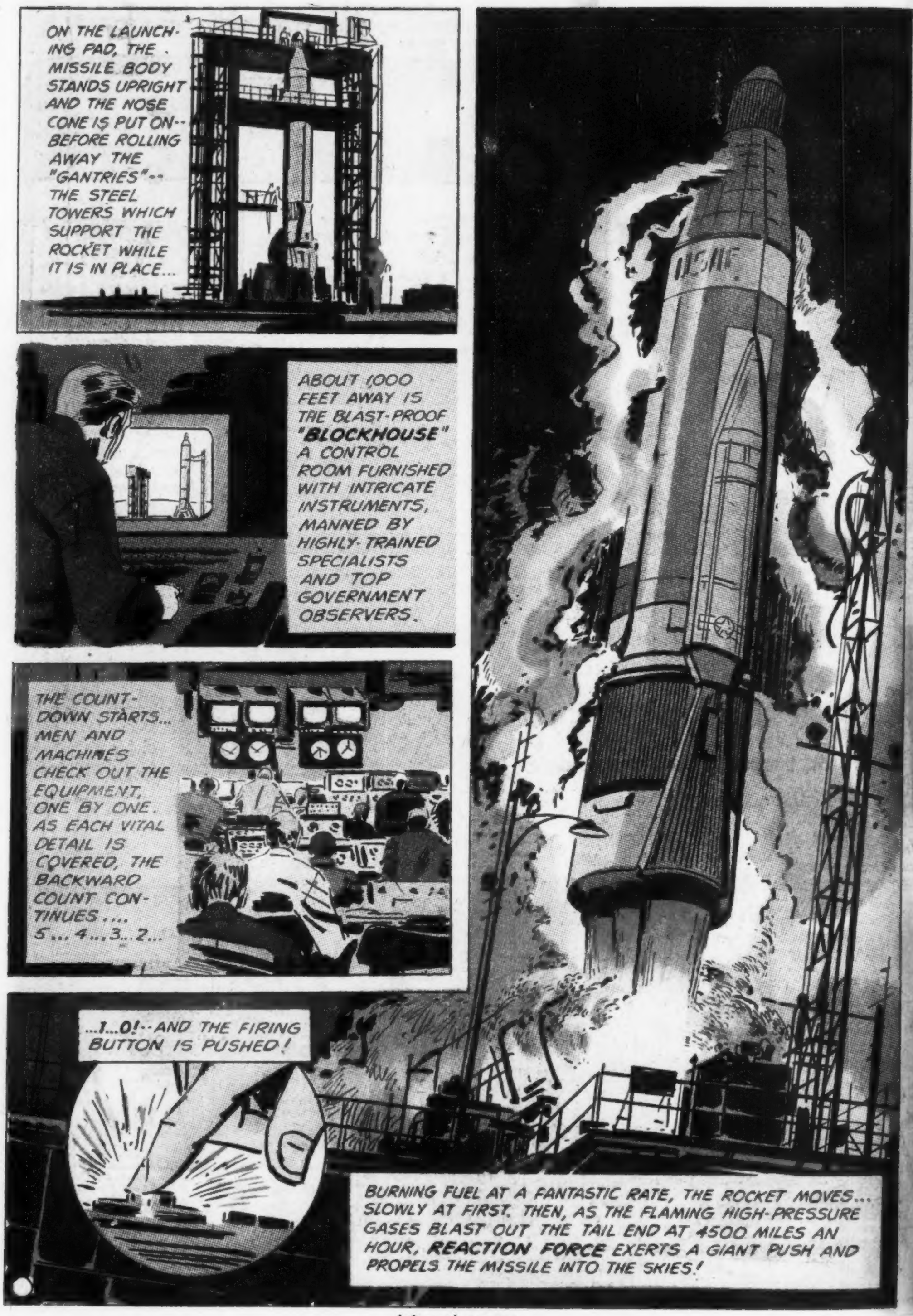

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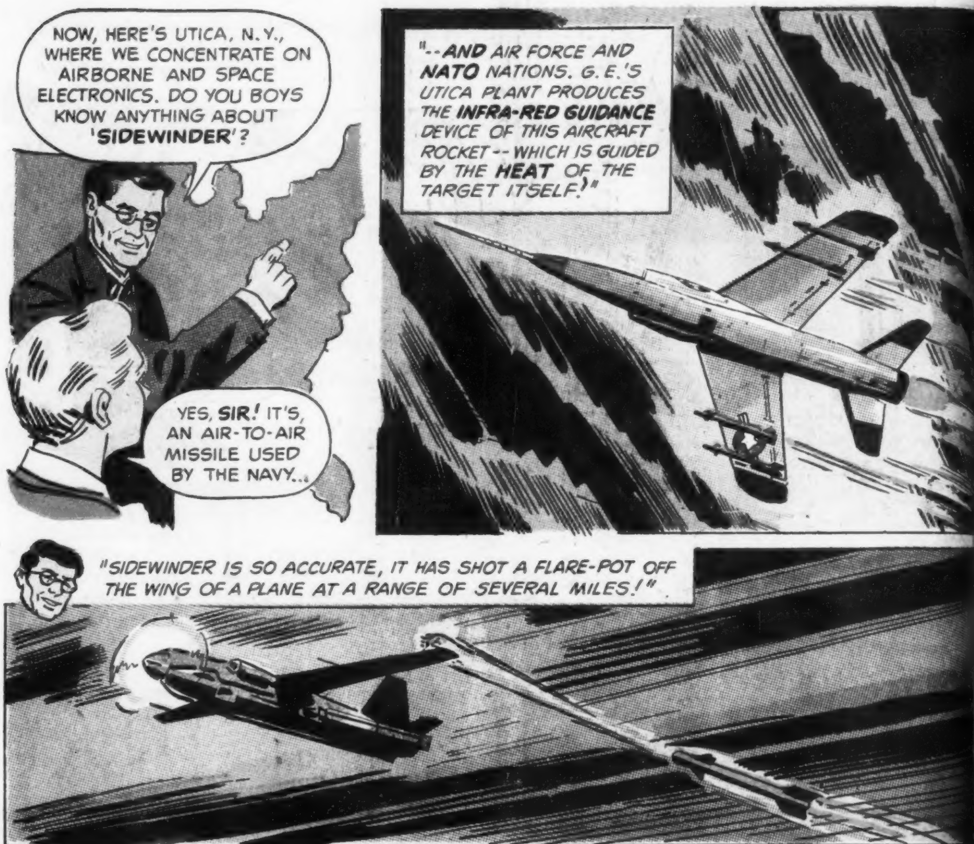

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Advertisement

Science in the news

Gravity Sickness

Gravity can make a man sick, as Captain Duane E. Graveline found out after living for a week without it.

Captain Graveline, an Air Force doctor, spent a week immersed in a king-sized bathtub. Pressure of the water made his body practically weightless.

After stepping out of the tub, he found that his muscles had become like dough and that his bones had softened. A few minutes after leaving the tank he became violently ill and had to climb right back.

Captain Graveline designed the experiment to test the effects prolonged weightlessness might have on space travelers. He was his own guinea pig. The temperature of the water in the 400-gallon tank was carefully controlled to remain at 91.4 degrees F. The Air Force doctor was clad in a skindiver's plastic suit, and strapped to an aluminum beach chair to keep from floating at the top of the tub. His head was supported out of the water on a foam-rubber pillow.

Climbing out after a week in the tank and subjected to normal gravity, he wobbled drunkenly, his movements were jerky, he breathed with difficulty, and slowly turned blue.

Tests showed that his blood pressure and pulse were abnormal, and his muscles and bones had softened. After being weightless for a week, gravity made him sick. He could talk clearly only after climbing back into his tub.

The experiment shows that unless artificial gravity is provided for an astronaut in space, he will suffer when he returns to Earth.

The young doctor expects his bones, muscles, and circulation to return to normal in a few weeks. One discovery he made while in the tub: he did not need much sleep. Weightlessness reduced his sleep requirements to only one hour a day. This may mean that astronauts will be able to work around the clock, or at least 23 hours a day.

Echoes from the Sun

Man may have made his first direct contact with the sun. Ten months ago Stanford University scientists directed powerful radio waves at the sun and received signals in return.

After analyzing the results, the scientists believe the signals picked up by their sensitive radio receivers had actually bounced off the sun's surface.

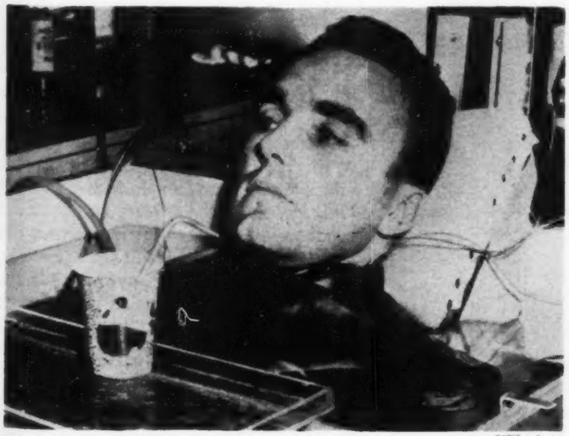
This is the most significant achievement to date in the young science of "radar astronomy," in which radar pulses are bounced off the planets. An Army Signal Corps group bounced radar signals off the moon in 1946. More recently, signals were bounced off Venus.

The radar contact with the sun was made with a 40,000 watt transmitter—the power of an average local broadcast station. The signals were beamed to the sun on a frequency of about 26 megacycles, and could have been heard on most short-wave receivers. The transmitter used a very large antenna of the type used by transatlantic short-wave stations. It took up five miles of wire and looked like a forest of telephone poles in a meadow. The sun was in the antenna's beam for only about 30 minutes after sunrise, and only during the few days a year when the sun is near the equinox. (This is the time of year when the sun is directly over the Equator. Days are the same length as nights all over the world. The sun crosses the Equator twice a year—about March 20 and Sept. 23.

The transmitter was turned on and off every 30 seconds for 15 minutes. Then the receiver was connected to the antenna to listen for the echo. Each radar pulse traveled to the sun and back to Earth in about 1,000 seconds, or 16 minutes (the sun is about 93,000,000 miles away, and the radar pulses travel at the speed of light, or 186,000 miles per second). The echoes were recorded on magnetic tape so that they could be analyzed in detail.

At this point in the experiment the scientists faced a real problem: How could they be sure the signals they heard were really echoes from the sun? The radio receiver was very sensitive. But a sensitive receiver picks up many extra radio noises—from the electron tubes themselves, from radio noise sources on Earth, from atmosphere, and from parts of the sun itself which send out very powerful radio waves.

To get around this problem, the scientists "coded" their transmitter by making it send out a *group* of radar pulses instead of a continuous sig-



UPI photo

Capt. Duane Graveline eats his supper while in tub full of water. Water's pressure opposes pull of gravity on his body.

Wide World photo

Stepping out of tub after seven days, Air Force doctor became very ill. Tub simulated weightlessness of outer space.

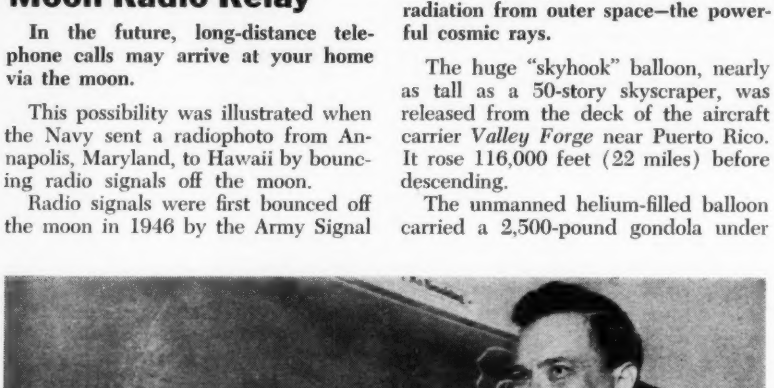
Science in the news

nal. If the signal later picked up by the receiver was "coded" in the same way, the scientists could be sure that it was the echo of their own signal.

An IBM computer was used to compare the received signal with the transmitted signal, to see how well it fitted the code. After six months the computer came up with the answer: The probability that the received signal was an echo was 100,000 to one, or almost certainty. The scientists could now definitely say that they had contacted the sun.

The computer also showed that the echoes were actually reflected from the sun's corona, the luminous envelope which surrounds the sun. The corona is about 500,000 miles away from the sun's visible surface.

Bouncing radar waves off the sun may help scientists forecast radio "blackouts" caused by sunspots and magnetic storms (*see pp. 13-16 this issue*).



UPI photo

Prof. Von R. Eshleman of Stanford University draws diagram showing how radar signals were bounced off sun. Signals took slightly over 16 minutes to make the 186,000,000-mile round trip. A 40,000 watt transmitter, huge antenna were used.

Moon Radio Relay

In the future, long-distance telephone calls may arrive at your home via the moon.

This possibility was illustrated when the Navy sent a radiophoto from Annapolis, Maryland, to Hawaii by bouncing radio signals off the moon.

Radio signals were first bounced off the moon in 1946 by the Army Signal Corps. Engineers now have succeeded in using the moon as a relay station.

Advantage of the moon relay: It uses ultra-high frequency radio waves (microwaves). Microwaves are unaffected by weather disturbances or even by magnetic storms which usually blanket out normal radio communications (*see pp. 13-16, this issue*). In the heavy magnetic storm of November 1959, the moon relay got through to Hawaii when all other radio links failed. Microwaves travel only in straight lines and cannot curve around the Earth. Only the moon or a satellite can bounce them back to Earth.

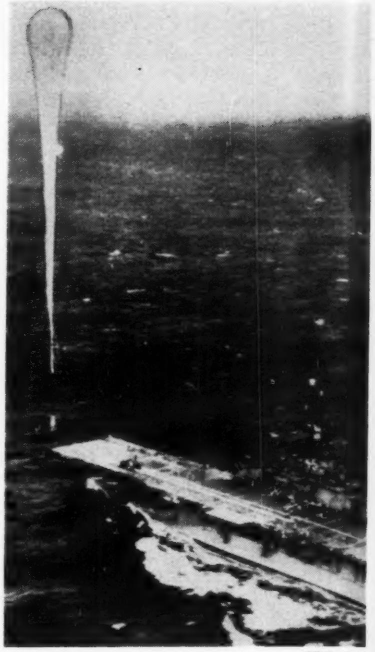
The moon relay has one disadvantage: The moon must be above the horizon at both sending and receiving points. In the case of Annapolis and Hawaii—4,580 miles apart—this period may last only five hours a day.

Biggest Balloon

The world's biggest balloon was sent aloft to take pictures of the elusive radiation from outer space—the powerful cosmic rays.

The huge "skyhook" balloon, nearly as tall as a 50-story skyscraper, was released from the deck of the aircraft carrier *Valley Forge* near Puerto Rico. It rose 116,000 feet (22 miles) before descending.

The unmanned helium-filled balloon carried a 2,500-pound gondola under



UPI photo

World's largest balloon is launched from aircraft carrier to study cosmic rays. The 50-story-tall helium-filled balloon carried 3,000 lbs. of scientific equipment to altitude of 116,000 ft. (22 mi.).

its gas bag. Inside the gondola were large blocks of photographic emulsion, similar to that on ordinary camera film. The emulsion was designed to record the impact of primary cosmic rays.

Primary cosmic rays are those rays from interstellar space which have not yet collided with atoms in the Earth's atmosphere. Such rays are 50 times more energetic than those found in an exploding atomic bomb. To avoid the effects of the Earth's atmosphere, the balloon had to rise 116,000 feet.

A balloon was used rather than a rocket because of the heavy payload. The stacks of photographic emulsion were seven inches thick and weighed 800 pounds. The thick stacks recorded not only the primary cosmic rays but the secondary particles as well. These were created when a primary ray collided with an atom in the emulsion. Only secondary particles and rays can be observed on the Earth's surface due to the density of the air.

The photographic emulsion should show the relation between primary cosmic rays in space and observations of cosmic radiation made on the surface of the Earth.

Navy planes followed the balloon until it neared the coast of Venezuela. To keep it from being lost in the jungle, the gondola was brought down

by radio command. It fell into the ocean and was picked up by a destroyer stationed in the area. By the time the gondola was fished from the sea, its plastic covering had been badly chewed by sharks, but the blocks of emulsion had remained intact.

Warmer Gulf Stream

The Gulf Stream has warmed up—about five degrees in the last 60 years.

A "river" in the Atlantic, the Gulf Stream originates between Cuba and Florida, flows along the eastern coast of the U.S., then curves northeastward toward Europe. The temperature of the Gulf Stream is important, for it helps determine the weather over the eastern coastal areas. Winds blowing west across the North Atlantic are warmed as they pass over the Gulf Stream, giving the coast a warmer and more even climate than inland areas.

Dr. J. Bjerknes of the University of California found the increase in temperature after studying North Atlantic temperature records from the 1880's to the early 1940's. Highest warming was along the Gulf Stream from North Carolina to the southern edge of the Newfoundland Banks.

Warming to a lesser degree was found in most other parts of the Gulf Stream, except for a small temperature decrease in a zone west of Ireland.

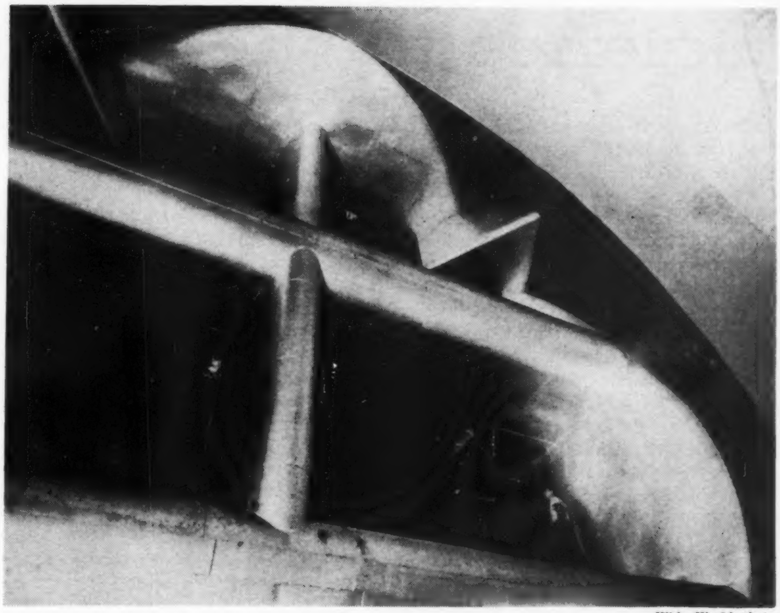
Although the Gulf Stream warming period has lasted through the 60 years measured, changes in surface temperatures over the rest of the North Atlantic show a warming and then a cooling every few years.

The rise in the Gulf Stream's temperature may be related to the general rise in the Earth's temperature discovered during the International Geophysical Year. Scientists have found that since 1912 parts of Antarctica have warmed by an average of five degrees. Temperatures are up about ten degrees on the island of Spitzbergen in the Arctic Ocean, and Arctic ice is one-third thinner than 60 years ago.

Two-Edged Virus

In 1951 a deadly infectious disease of rabbits called myxomatosis was deliberately introduced into Australia. The disease swept rapidly over immense areas, wiping out almost every rabbit that contracted it.

Myxomatosis is a virus disease, dangerous only to the common European rabbit. It is carried by the mosquito and is nearly 100 per cent fatal. The virus was released in 1950. Four years later the disease had spread to all of southeastern Australia.



Wide World photo

Huge supersonic wind tunnel will create winds up to 3,000 mph to help Air Force solve space travel problems. "Grille" in which man stands cools air before it reaches test section. Heat is absorbed by circulated water—65,000 gals. per min.

Myxomatosis was a boon in Australia, where it helped to wipe out a rabbit nuisance causing millions of dollars of damage each year.

The following year the disease migrated to England, where rabbits were also damaging vegetation. It spread slowly at first, until man decided to give nature a hand. Eager to clear the countryside of rabbits and improve vegetation, the Ministry of Agriculture spread the disease by turning loose infected rabbits. It wiped out about 100,000 rabbits.

Soon there were few rabbits to be seen. Vegetation began to change. In some places ground cover improved. There was a greater range of grass species, many more nutritious to livestock. Even the soldier orchid, a wild orchid believed extinct in Britain, began to flower. With no rabbits to nibble tender roots, many plants began to grow luxuriantly.

But the delicate balance of nature had been upset. Disturbing signs began to appear. Flowers were unable to withstand the new competition from coarse grasses and woody plants, which rabbits once held in check. Meadows became choked with coarse grass. Ground-loving birds, such as larks and wheatears, had trouble finding food.

Last year there was some hope the trend might reverse itself. New and weaker strains of myxomatosis developed. Only about half the remaining rabbits were becoming infected. Most of the surviving rabbits became immune. Rabbits have increased to nearly 10 per cent of their previous number.

But Britons fear that some places will never be the same—a scarred reminder of unscientific meddling with nature's delicate balance.

Antibodies

The intricate process by which the body's natural defenses deal with foreign invading cells has been identified.

Dr. Howard Green and Dr. Burton Goldberg of the New York University College of Medicine have found that the defense substances—antibodies and a protein substance called *complement* —apparently act by making minute "holes" in the outer membrane of an invading cell. The holes permit a rapid and abnormal flow of cell materials into and out of the invading cell, upsetting its balance. The cell begins to swell.

The swelling causes the holes to stretch. More materials essential to the cell's normal functioning escape. Their escape kills the cell.

Complement is the chief factor in producing the holes. It has been known for decades that antibodies and complement act together against a foreign invader, but the report by Dr. Green and Dr. Goldberg is the first thorough analysis of the process of the antibody and complement attack.

This research has given scientists

Science in the news

new clues to the important question of how the body reacts to foreign cells. It also sheds light on the question of what happens when tissue is transplanted from one individual to another. (The January 13 issue of *Science World* described the antibody reaction to transplanted tissue.)

Dr. E. A. Zotikov of the Institute of Experimental Biology, Moscow, has reported that if a piece of transplanted skin is sufficiently large, it may overwhelm the body's natural defenses, which tend to reject it.

Skin grafts from one person to another ordinarily slough off in a few days or a few weeks. In Dr. Zotikov's experiments skin grafts were made involving more than one third of a rat's body. In some instances the transplants survived more than eight months.

If medical scientists solve the problem of skin grafts, they will be able to restore the scarred tissue of burn victims, and replace diseased organs with healthy ones.

Carp Poison

In New York State carp are breeding at such a rapid rate that they threaten to upset spawning of prized game fish by rooting up lake and river bottoms while feeding.

Scientists are seeking a practical carp-killing poison. In the search they have uncovered a weakness in carp for certain flavors. This weakness may lead to their undoing.

Howard A. Loeb and William H. Kelly, fishery biologists with the New York Department of Conservation, have discovered that a few drops of a carp-cherished flavor squirted into a tank will cause the carp to start looking wildly for food. Some of the flavors carp like are tobacco juice, instant coffee, and especially imitation maple. By disguising an unpalatable poison with one of these flavors, the carp will take the poison readily.

To date more than 1,700 poisons have been tested, with some 500 poisons still left to be tested. Of all poisons tested, 135 have proved to be good carp killers in force-feeding. But when the poisons were dropped into a tank the carp detected more than half of them and spit them out. A dozen of those tested seemed effective.

The two scientists get many inquiries concerning their work. "And then, there's always the reverse twist," says Mr. Loeb. "Here we are, trying to get the carp out of the waters so the other fish'll be happier. Over in Israel they raise carp commercially for food. The other day we had an inquiry from Israel—they wondered whether we could help on a problem they had. Other fish were invading their carp ponds."

Dive 7 Miles Deep

Teeth chattering from the cold, Dr. Jacques Piccard and Lieutenant Don Walsh climbed out of the Navy's bathyscaph, (Trieste), after diving to a depth of 37,800 feet in the Marianas Trench.

They had gone deeper than man had ever dived before.

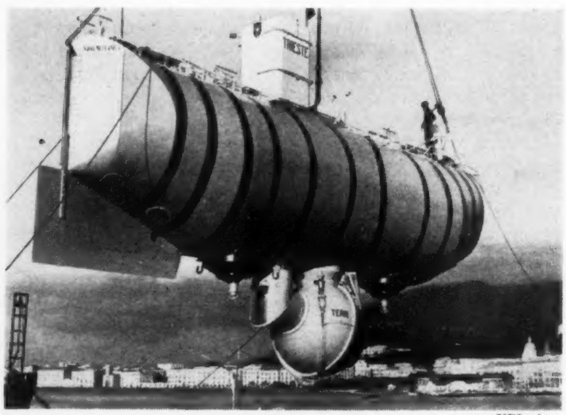
This was the same two-man team that on January 7, 1960, made a record dive of 24,000 feet in the same Marianas Trench in the South Pacific. During their latest dive, they had gone farther below sea level than Mt. Everest rises above sea level (29,028 feet). The Marianas Trench, an underseas canyon, is believed to be the deepest depression in the oceans.

The two scientists encountered no difficulty during the probe. They spent about one-half hour on the bottom and reported seeing living and moving objects at 37,800 feet. One of the major discoveries: fish living at such great depths. This finding indicated that both fish and water currents are found at that depth. Some scientists had believed that the ocean depths were a safe burial place for radioactive wastes. The presence of currents indicates that radioactive material dumped there would eventually rise to the surface.

The two scientists also experimented with the transmission of man-made sounds under water. Information on the behavior of sounds under water is important in the development of improved sonar devices for detecting enemy submarines.

The bathyscaph carries equal weights of gasoline and steel shot. It is submerged by evacuating air from the end chambers and replacing it with water. At the end of the dive, when the scientists wish to surface, the shot is released at the bottom and the buoyant gasoline floats the bathyscaph back to the surface. Maneuverability is provided by electric-powered propellers. The hull of the 75-ton bathyscaph sustained a pressure of 16,884 pounds per square inch at a depth of 7.15 miles.

On February 4, the two divers were presented with citations by President Eisenhower.



UPI photo

Deep-sea diving record of 37,800 feet (over 7 miles) was set by bathyscaph *Trieste*, shown being lowered for trial run. Two-man crew rode "bubble" below hull of 75-ton diving craft.

UPI photo

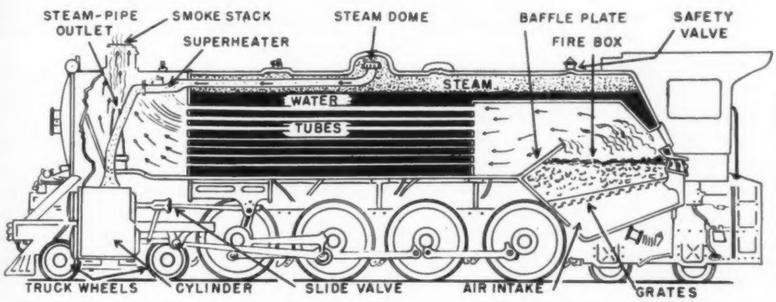
Scientists aboard auxiliary ship checks bathyscaph's descent on precision depth recorder. Descent was made in Marianas Trench in South Pacific, world's deepest undersea canyon.

What Happens and Why

By THEODORE BENJAMIN

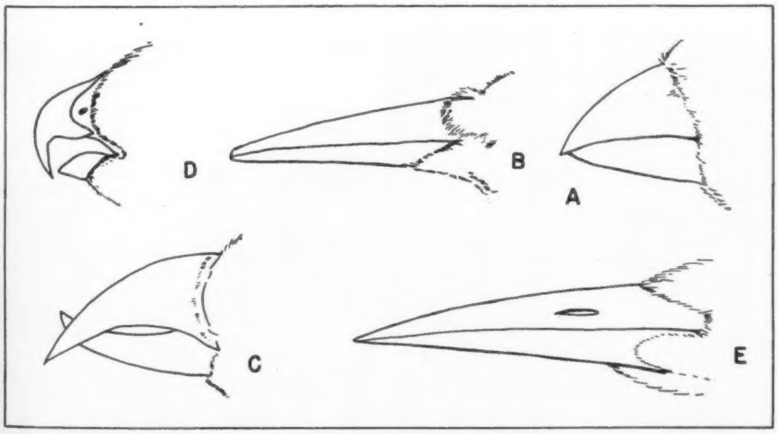
A picture is worth a thousand words, according to an old Chinese proverb. Nevertheless, to get the sense and importance of a picture we must be ready to translate the picture into words. In fact, some newer types of examination questions test your ability to examine a picture or diagram, determine from it the basic principles involved, and then, drawing on your background of previously accumulated knowledge, find out how well you can answer questions about the picture.

Here are several such story-pictures. See how well you can use your powers of observation and knowledge to answer the questions proposed for each.



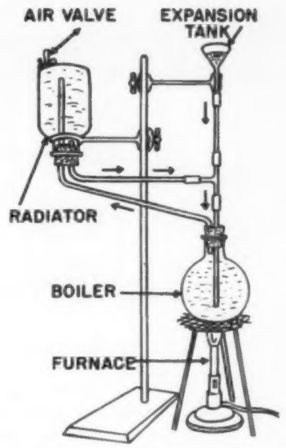
The above diagram is a cross-sectional view of a typical old-fashioned steam locomotive. After examining the diagram see if you can answer these questions.

1. Why is an air intake necessary?
2. Why is the steam pipe which leads to the cylinder begun in the steam dome?
3. What is the purpose of the superheater?
4. What is the purpose of the slide valve?
5. Why is the steam-pipe outlet, which carries the exhaust steam from the cylinder, exhausted through the smoke stack together with the combustion gases?
6. Why does a locomotive puff?



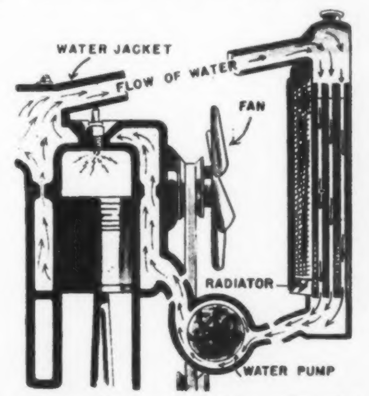
Carefully examine each of the different types of bird bills shown above. Each is especially adapted for a particular type of feeding. For each of the descriptive statements below, select the type of bill which is best adapted for the purpose and give your reasons for selecting this type of bill.

1. This bird eats hard seeds.
2. This bird extracts seeds from cones of evergreens.
3. This bird feeds on fish and frogs.
4. This bird eats the flesh of animals.
5. This bird drills into wood for insects.



This diagram shows a working model of a hot-water heating system. Examine the diagram to determine the principle of operation and then answer the questions below.

1. What is the purpose of the expansion tank?
2. Why must the air valve in the radiator be opened when the system is being filled?
3. Why does the pipe carrying the hot water from the boiler start from the top of the boiler?
4. Why does the return water from the radiator enter the boiler at the bottom?
5. What are the advantages of the hot-water heating system, when compared to the steam-heating system?

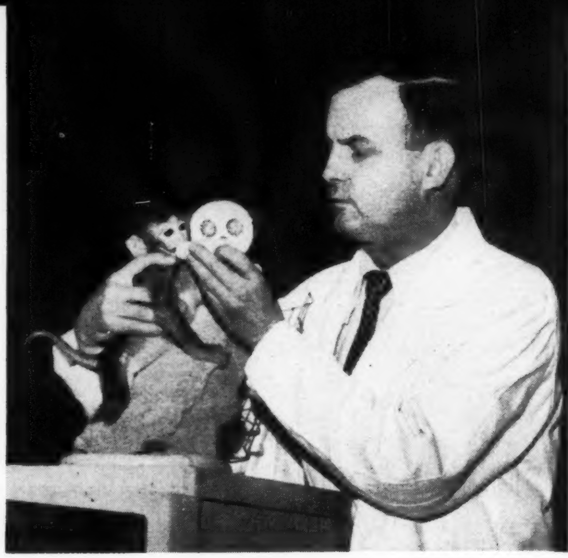


The cooling system of an automobile is shown in the diagram above. Study it carefully and then answer the questions below.

1. Why is the radiator made of copper tubing and built like a honeycomb?
2. What is the purpose of the fan?
3. What would happen if the fanbelt were to break?
4. What is the purpose of the water pump?
5. Why is the heated water returned to the top of the radiator, rather than to the bottom?

today's scientists

Dr. Harry F. Harlow
Exploring Behavior



Baby rhesus monkeys and terry cloth "mothers" are laboratory equipment used by Dr. Harlow to explore monkey's love for its mother

"IT'S Love that makes the world go round," wrote W. S. Gilbert—the writing half of Gilbert and Sullivan. But since the days of ancient Greece, poets and philosophers have tried vainly to understand its elusive nature. Today scientists are searching for this understanding with the help of a group of hungry-eyed baby monkeys and a fantastic monkey scarecrow.

At the Primate Laboratory of the University of Wisconsin at Madison, Dr. Harry F. Harlow and his associates are conducting experiments designed to explore the behavior of an infant toward its mother.

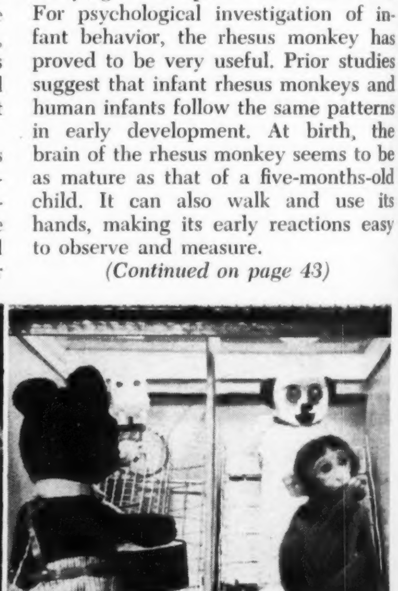
Dr. Harlow is a psychologist who has spent many years studying animal development and behavior. Born in Fairfield, Iowa, on Halloween in 1905, he began his scientific studies at Stanford University in California. In 1930, after receiving his Ph.D., he was appointed to the faculty of the University of Wisconsin.

As director of the Primate Laboratory, Dr. Harlow's chief interest has been the infant development and learning of monkeys and other primates. Much of the knowledge man has gathered about himself he has learned studying other species of animal life. For psychological investigation of infant behavior, the rhesus monkey has proved to be very useful. Prior studies suggest that infant rhesus monkeys and human infants follow the same patterns in early development. At birth, the brain of the rhesus monkey seems to be as mature as that of a five-months-old child. It can also walk and use its hands, making its early reactions easy to observe and measure.

(Continued on page 43)

Photos by Sponholz. Courtesy of Conquest program, CBS News

Wire, terry cloth, and a wooden head spell "mother" to experimental monkey in Dr. Harlow's lab. Frightened in strange place by strange objects, monkey clings to soft cuddly "mother" for comfort, feels safe, then studies the objects calmly.



With eyes flashing, making fearful noises, mechanical bear frightens infant rhesus monkey. Comforted by contact with terry cloth "mother," monkey feels safe. Fear diminishes. Infant monkey never seeks wire "mother," even if fed from bottle held by her.

tomorrow's scientists

Project: Crystallography

Student: James Birk
St. Boniface High School
Cold Spring, Minnesota
Science Achievement Awards Winner
Teacher: Sister Bernice

WHEN you were reading Eliot Tozer's article "Secrets of the Big Ice," did you wonder how scientists learn about the internal structure of ice and zinc crystals—how they measure the rate of crystal growth? The scientific study of crystals—crystallography, it is called—is a neat example of scientific investigation. In looking back—from our present knowledge of crystals to the beginnings of man's interest in them—we can get a good image of how the study of crystals reflects scientific progress.

Quite possibly the first crystals to attract man's attention were large and beautifully colored gem stones, whose beauty depends not only on color but on the reflection and refraction of light from their many-angled surfaces. Without understanding the source of their beauty, man, from the beginning of civilization, has adorned himself, his wife, and his precious possessions with gems. And in learning to tell one gem from another—good ones from poor ones, and how to cut them to desired shapes—a body of knowledge was accumulated, the beginning of a science.

Later, when wonder about the history of our planet led men to look closely at rocks and minerals, they noticed that most had a typical crystalline structure. Observation led to speculation—speculation led to hypotheses. Hypotheses required controlled tests for verification or rejection.

Scientists thought, "If we can grow crystals under carefully controlled conditions in the laboratory, we may learn something of the processes of nature."

When you see an unexplained event or process, and you begin to think of some method of duplicating the process under controlled conditions so that you can learn more about it, you are thinking scientifically.

James Birk wondered about crystals and planned his project to learn more about conditions under which they grow.

JAMES BIRK'S PROJECT

Crystals are solids in which the atoms or molecules are arranged in definite and repeated patterns, so that their faces intersect at angles characteristic for each crystalline substance. I chose the study of crystals because they are so widespread and important in our daily life. The sugar and salt we use are crystals. All metals are crystalline, and by studying crystal bonds we can find ways to make metals stronger.

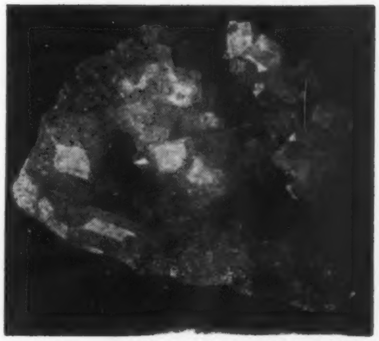
I knew very little about crystals and could find only a few basic facts in the texts available to me at the time. Because of this, I had to learn from experience and experimentation. The first problem I ran up against was growing the crystals.

Problem of Growing

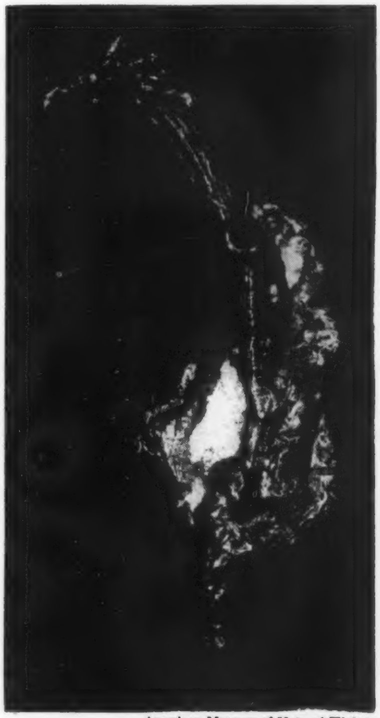
I decided to work on a small scale at first and grow some seed crystals—small crystals that could be used as patterns for larger ones. Using distilled water to eliminate as many impurities as possible, I took a number of salts and dissolved as much of each as I could in about 40 ml.

I heated the solutions every night and added the salt until I had achieved saturation. When the water evaporated, small crystals were formed. In order to know what kind of crystals to expect, I had previously put a sample of each saturated solution on a microscope slide and examined the crystals as they formed. When the seed crystals reached a size of about 4 or 5 mm. to a face, I selected the more perfect ones and set them aside for future use.

The next step was to grow large crystals from supersaturated solutions. I chose to grow crystals from supersaturated solutions for several reasons. By using supersaturated solutions rather than evaporation, I would not have to mix solutions so often. This would make the solutions much the same every time and give me better controls over my experiments.



American Museum of Natural History
Crystals of sulphur found in nature.



American Museum of Natural History
Metallic crystals of native silver.

I had read that best results could be obtained if the solutions were kept from cooling at night and warming up in the daytime. At first I had some trouble working out a way of doing this. Finally, I placed the beakers of solution in a tank of water with a thermostatically controlled aquarium heater. I kept the water at a constant temperature of 70° F. Controlling the temperature prevented abnormal rates of dissolving during the day and crystallization at night. I also made caps for the beakers to prevent evaporation and keep out falling dirt and dust.

10 Salts—44 Solutions

I tried to fasten the seed crystals to string in a number of different ways, so I could hang them in the solutions. Different glues and tapes, paraffin, wax, collodion and even chewing gum were tried. None of these held onto the smooth surfaces of the seed crystals. Then I tried tying the string around the crystal. This worked quite well. Working my way up out of this problem taught me a simple but important lesson: the best procedure is the simplest and most uncomplicated procedure that works.

The crystals grew through ion exchange. If the solution was supersaturated, the rate of ion deposit on the crystal would be greater than the rate at which ions passed back into solution. The crystal then would grow. However, at times crystallization on the bottom of the beaker would be more rapid than on the crystal hanging in the solution. When this happened, I took the growing crystal out and heated the solution to 130° F. for five minutes. Some of the crystals on the bottom would dissolve and the solution would once again be supersaturated. By keeping records, I soon found out how often this was necessary; once every two to four days, depending on the strength of solution and rate of crystal growth.

Rates of Growth

During this series of experiments on crystal growth, I have experimented with ten different salts in 44 different solutions. The crystals grown vary in weight from 0.3g. to 38.1g. When the total weight is divided by the days of growth it is possible to get a rate of growth. This varied from 0.017g./day for sodium chloride to as much as 1.86g./day for magnesium sulfate. However, all the samples of one kind of salt did not produce crystals at the same rate. The fastest growing crystal of magnesium sulfate crystal grew more than 12 times as fast as the slowest one.

In observing the growth of sodium potassium tartrate, Rochelle salt crystals, I found that at times the bond between layers didn't hold. Some of the layers broke off, leaving a rough surface instead of the usual smooth surface. My theory is this: they grew so fast that the bond between layers was weak. After three crystals were ruined because of this, they began to grow normally. It may be that the solution became less saturated due to the loss of salt to the first three. Thus the rate of growth slowed down, making stronger bonds between the layers. I will have to repeat this experiment several times before I can be sure of this explanation.

American Museum of Natural History
Copper crystallized by nature.

I then grew Rochelle salt crystals hanging in various positions. Although the size of the faces differed quite a bit, the angles were the same for all.

Crystals Repair Themselves

Some crystals have an amazing ability to repair themselves. On December 31, 1958, I discovered a second crystal growing on the side of a large Rochelle salt crystal in solution. I removed the second crystal, leaving a hole in one third of the side. By next morning there was no visible trace of the hole!

At present I am working on magnesium sulfate in an attempt to find out whether crystals growing side by side influence each other. I tie two or more seed crystals together and suspend them in solution.

I am doing this to check a hypothesis that some of the variation I have found in the angles of magnesium sulfate crys-

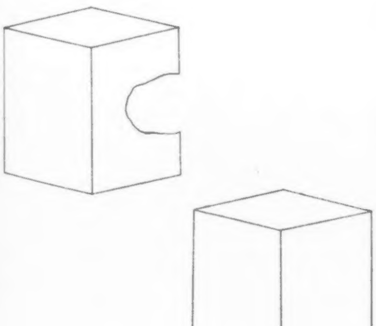
G. E. photo
In a setup somewhat more elaborate than Jim Birk's, General Electric scientists grow extremely pure crystals by the process of "zone refining." Superpure crystal *(inset)* will be used for study of silicon properties.

tals is due to the influence of other crystals growing at the same time.

In connection with my project I have constructed an ionic model of sodium chloride showing how the ions bring about the shape of the crystal. The model can also be used to demonstrate crystallization and dissolving. At present, I am growing two or three samples of as many crystals as possible in order to make a standard of comparison for identifying unknown salts.

UPI photo

Metals are crystalline. This 99.99% pure bar of chromium is expected to play a role in space age alloys.



Crystals can repair themselves. Hole left by removing small crystals was repaired overnight.

Project: A Secondary Time Source

Student: William McGinnis
Robbinsdale Senior High School
Robbinsdale, Minnesota
Student Achievement Awards Winner
Teacher: Ethelyn C. Tellers

CERTAIN crystals, such as Rochelle salt and quartz, have the property of generating an electromotive force when compressed. This is known as the *piezoelectric effect*. The interesting thing about the piezoelectric effect is that it is reversible. A mechanical strain applied to the opposite faces of a quartz crystal will generate a voltage. Conversely, if a voltage is applied to the two parallel faces of the crystal, a mechanical strain occurs in the crystal, producing an electrostatic field, which in turn produces a strain. This process goes on.

Each alternation between mechanical strain and electrostatic field is called a *cycle*. The number of times the cycle occurs each second is called the *frequency* of the crystal. The frequency of a good crystal is remarkably constant, and a crystal may be cut so that its frequency may be thousands and even millions of cycles per second. When used in this way, a crystal together with its associated circuit is called a *crystal oscillator*.

WILLIAM McGINNIS' PROJECT

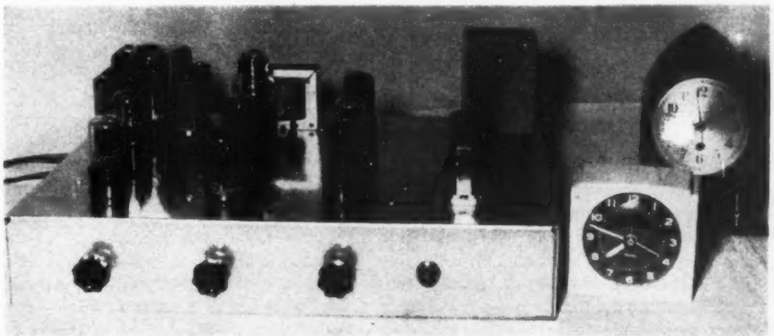
My interest in physics and astronomy led to the desire to make independent measurements of the variations in the length of time from noon to noon at my location. An ordinary synchronous clock using electricity from the power line would not be accurate enough for this purpose. The power company cannot keep its line current exactly on 60 cycles, due to changing load conditions (the demand for power by users varies during the day). Since the oscillations of a quartz crystal are very accurate and constant, I thought that a crystal could be used to provide an accurate frequency to run an electric clock.

The circuit is simple and consists of a 120,000-cycle oscillator coupled to a series of electronic components called *multivibrators*, which reduce the frequency to 60 cycles. The 60-cycle frequency is fed into an amplifier which runs the clock.

Adjusting the Frequency

I had read about a similar device in which the experimenter told of having great difficulty in getting the multivibrator stages to operate in a stable manner. I felt that was due to having the multivibrator stages divide by 20 from 120,000 cycles to 60 cycles. After some experimentation, I devised a circuit so that the division from 120,000 cycles to 30,000 cycles is done in two steps, and then on to 6,000 cycles. Since the initial adjustments, the multivibrator stages have operated with great stability.

Another problem involved the crystal oscillator. When the multivibrator stages were operating correctly, the crystal adjustment was begun. The clock gained



The key to an accurate time source is an oscillator of known frequency. Oscillator, multivibrator and amplifier are housed in chassis and hooked to white clock.

tomorrow's scientists

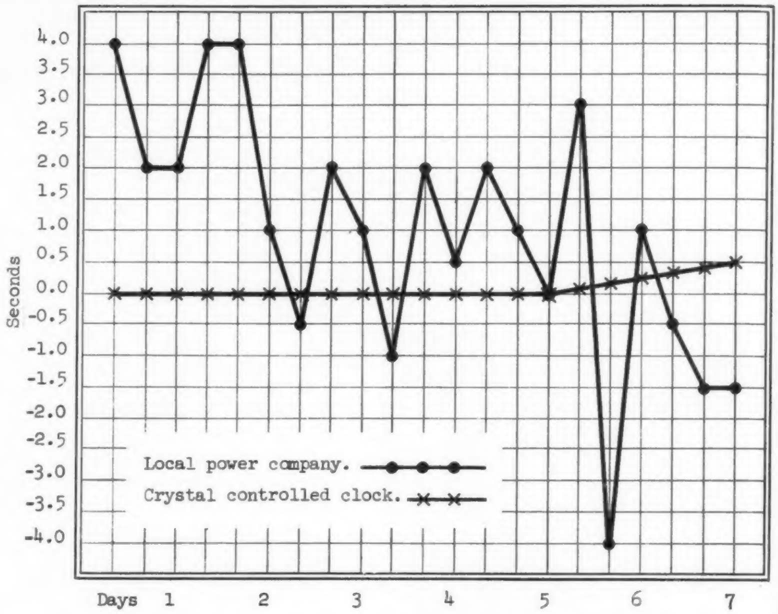
33 seconds in about 12 hours. When I found that much adjustment to the circuits would not correct this, I decided to measure the crystal's frequency. The 120,000-cycle crystal, which had been guaranteed within six cycles, was 90 cycles off. After a new crystal was received, it took a few weeks to adjust it to the proper frequency.

The United States Bureau of Standards maintains the primary time standard and broadcasts time signals. My clock was adjusted to these signals and has remained accurate for several days.

No Perceptible Variation

According to my records, variations in a clock running directly from the power line have been as great as five seconds in three hours. My clock runs with no perceptible variation. Over a long term my clock would be even more accurate with a crystal oven to maintain the crystal at a constant temperature.

With this degree of success in establishing my secondary time standard, I am now ready to go on with my study of the variations in the length of the solar day.



While a clock on city power varied as much as 7 seconds in 24 hours, Bill's crystal-controlled time source varied only 0.5 seconds in 7 days.

Project and Club News

Project Idea From This Issue

It isn't hard to collect slime molds so that you can have some available for experimental work. Slime molds are widely distributed and easy to "capture and tame." Many species may be taken throughout the year, but they seem to be most abundant in autumn. However, a few days after a spring rain, a little searching under the bark of dead and fallen trees, on rotten wood, and under rotting boards should reveal the flat yellow or white plasmodia of slime molds. *Stemonitis* may be found on numerous species of decayed wood. *Lycogala* is particularly common on dead beech and pine logs. You can find pictures of these representative types in most standard botany texts.

Collecting: Cut out pieces of wood bearing the specimens and glue them to the bottoms of penny match boxes. This will permit you to transport the fragile specimens without breaking. Plasmodia can be stored in this way if dried, but they will usually produce sporangia overnight.

Culturing: Take some of the pieces of wood bearing plasmodia and place them in a deep jar (a large pickle jar or syrup jar from the nearest fountain or drive-in will do nicely) in contact with several pieces of damp paper toweling. If the plasmodia are fed with finely ground instant oatmeal (grind it in a clean mortar), they will thrive and spread to the toweling. Keep the culture moist, in the dark, and well fed. Do not overfeed!

After the culture has spread to the toweling, pieces of it may be removed, air dried, and stored in envelopes for a year or more. You can start new cultures by providing a moist environment and feeding as the plasmodia grow.

Research: Generally, fruiting will not take place on the paper medium. Can you induce your paper-grown slime molds to fruit by controlling their environment?

College Help for Clubs

Has it occurred to you that a college might help you to get the feel of becoming a scientist—while you are still in high school?

Many regional and area science fairs are sponsored by universities and colleges. In these cases, the campus often serves as a center of ideas, information, and advice.

If there is a university within reach of your school, your science club may find sources of various kinds of help there, whether or not the university has any connection with your science fair.

Professors usually are glad to discuss specific problems, to refer a puzzled projecteer to the most useful books and scientific papers in the university library, to explain the "hard spots" that are frustrating further progress on an experiment, to serve as project counselors, career advisors, or general speakers for science club meetings, and to serve as judges at your science fair.

In some areas the science club is invited, or can arrange to be invited, to a high school project workshop or series of workshops on the campus. These often are all-day affairs and may include demonstrations, exhibits, advice, and even distribution of certain basic materials by the physics, chemistry, biology, and mathematics departments.

Saturday morning seminars for outstanding high school students have been tried experimentally and have proved to be highly popular and productive. Such seminars offer advanced work in mathematics and the sciences, meeting on a regular basis during the school year.

Occasionally a university can allow an advanced high school student the unusual privilege of carrying out some of his experimental work in a college laboratory or can arrange to lend him an essential piece of equipment. Graduate students working as research assistants have been known to act as advisor-critics to high school students who are seriously interested in their special fields.

It is sometimes possible for individual students or an entire science club to attend a lecture given at the university by a distinguished scientist.

The dean of admissions probably would be glad to speak to your school or to your science club on preparing to enter college, choosing your high school curriculum to fit future college plans, scholarship opportunities, and similar important topics.

It is possible, also, that a few top level science students might be given part-time or summer jobs as laboratory assistants on the campus. This has been done with fine results by several universities.

If your club has not had previous contact with the university, it would be wise to establish your first one through the principal of your school or through your club sponsor or science faculty members. When suggesting that special privileges and opportunities be made available to your members, you would be careful, of course, to screen such requests through your club sponsor and to ask them only for intensely interested and competent students whose response would be sincerely appreciative and mature.

Obviously the science club cannot be encouraged to arrive en masse on the campus. It would be best for you to make all requests through your club sponsor, and perhaps to enlist the cooperation of some of the alumni of your school now enrolled at the university.

Answers to Crossword Puzzle

(See page 46)

O	S	M	I	U	M		S	I	L	V	E	R
X	E		O	R		G		T	I		N	A
Y	B		N		T	O	N		P		A	D
G	U	M			A	L	A			S	C	I
E	M		A	G		D		L	I		T	U
N		T	R	A	M		R	E	N	T		M
	R	I	G	I	D		R	A	D	O	N	
C		N	O	T		T		D	I	N		H
A	H		N		L	E	T		A		A	E
R	E	D		B	O	R	O	N		B	D	L
B	I		O		G	R	O		M		I	I
O	D		A	S		A		A	U		E	U
N	I	C	K	E	L		I	N	D	I	U	M

Exploring Behavior

(Continued from page 38)

Dr. Harlow's interest in affection developed through earlier studies he had conducted with infant monkeys. He had separated a group of newborn monkeys from their mothers, to see whether they could be kept alive in the laboratory through proper feeding techniques. He found that these infants thrived. In fact, they were far healthier than control monkeys that had been fed by their mothers.

During the course of the experiment, however, he noticed that the infants were happy only when they had something soft and pliable to hold, such as the soft diaper that was placed on the floor of their cages. When these were removed the monkeys became unhappy and disturbed.

Need to Cling and Cuddle

"This simple, basic reaction," Dr. Harlow explained, "made us believe that we could define and measure what had previously been undefinable and unmeasurable—a baby's love for its mother." Many psychologists believe that an infant's love for its mother is derived from the fact that its mother nurses it.

"But is it possible," Dr. Harlow suggested, "that this love is formed from a need to cling and cuddle?"

Defining the undefinable is not a simple task, even for a scientist. True, Harry Harlow had found the perfect experimental subject in the monkey. But how was he to create the perfect experimental *mother,* one which was inanimate, over which he would have complete laboratory control, but still one which the baby would love?

Using the ingenuity of the artist as well as the scientist, Dr. Harlow and his group constructed two unusual substitute mothers. One was a wire cylindrical form topped by a wooden head with a crude face, built exactly to rhesus monkey mother size. The other was designed the same way, except that the wire cylinder was covered with soft terry cloth.

"These are very remarkable mothers," Dr. Harlow said. "They have absolute patience. They are available twenty-four hours a day. They never scold or strike their babies in anger."

Armed with this ingenious experimental device, Dr. Harlow could test his theory that love was derived from close body contact with the mother—"contact comfort," as he called it. He placed eight newborn monkeys in individual cages. Each had equal access to a cloth and a wire mother of its own. Four of the monkeys were nursed by a bottle set into the body of the wire mother, and four by a bottle in the cloth mother. Both mothers were available at all times.

Dr. Harlow had believed that contact comfort would be a factor of great importance. He was amazed to find how really important it was. Each group of infants spent the greater part of the day clinging and climbing on the cloth mother. Those that had been nursed on the cloth mother almost totally ignored the wire mother. Those nursed on the wire mother spent only the time necessary for feeding there. Once fed, they immediately ran to the soft terry cloth mother.

Actual test results showed that the infants reared on the wire mother spent less than one hour a day in her company, and from 17 to 18 hours a day with the cloth mother. This dramatic evidence seemed to contradict the theory that love is formed through nursing alone.

But is this really love? Or is it merely the tendency of an infant monkey to cling to something soft. Tests under emotional stress have given a partial answer.

"If a frightened baby went running to its mother, was comforted, and then all the fear disappeared and was replaced by a complete sense of security, would that not mean that the baby loved its mother?" Dr. Harlow asked.

Love and Security

To frighten the monkeys thoroughly, his group devised a series of diabolically fearful figures with clanking mechanical parts and flashing eyes. When these fiendish noisemakers were placed in the infant's cage it would invariably run, terror stricken, to its cloth mother. Once it had been comforted through contact with the mother, the monkey was able to look at this object—which had previously struck terror in its heart—without the slightest fear. Sometimes it would even gain the courage to leave the mother and explore the figure.

"But one type of test doesn't make a theory," said Dr. Harlow. He explored his ideas further in a different experimental area, which he calls the Open Field Test Room. Specially designed for these studies by Dr. Robert Zimmerman, one of Dr. Harlow's associates, this room was much larger than the cages to which the monkeys were accustomed. It contained a number of objects unfamiliar to them, such as a doorknob, a small artificial tree, wooden blocks, and a crumpled piece of paper.

If the infant was placed in this room without any mother, it ran to a corner,

(Continued on page 45)

BRAIN TEASERS

Find the Error

A coffee company made a survey of the number of people who drink tea and coffee. An investigator handed in the following report to the president of the company:

Number of people interviewed	100
Number who drink coffee	78
Number who drink tea	71
Number who drink both tea and coffee	48
Number who drink neither tea nor coffee	0

When the president read the report, he noticed a mistake and fired the interviewer. What was the error?

Don Olen
Brooklyn (N. Y.) Technical H. S.

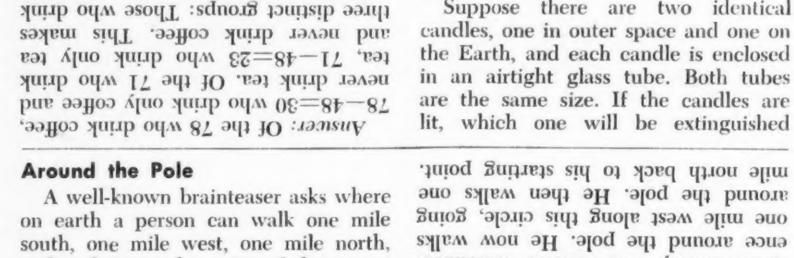
Answer: Of the 78 who drink coffee, 78—48=30 who drink only coffee and never drink tea. Of the 71 who drink tea, 71—48=23 who drink only tea and never drink coffee. This makes three distinct groups: Those who drink only coffee (30), those who drink only tea (23), and those who drink both tea and coffee (48): a total of 101 people. But the investigator gave the number of people interviewed as only 100, which means one of his figures was wrong.

Around the Pole

A well-known brainteaser asks where on earth a person can walk one mile south, one mile west, one mile north, and end up at the point of departure. The usual answer is, of course, the North Pole. However, there are other places on earth for which this is true. Where are these points and how many of them are there?

James Post
Las Cruces (New Mex.) H. S.

Answer: Our hiker can leave from any point which is exactly $1 + \frac{1}{2\pi}$ miles from the South Pole. Suppose a person leaves from a point $1 + \frac{1}{2\pi}$ miles from the South Pole and walks one mile south. He is now $\frac{1}{2\pi}$ miles from the pole. This is the radius of a circle exactly one mile in circumference around the pole. He now walks one mile west along this circle, going around the pole. He then walks one mile north back to his starting point.

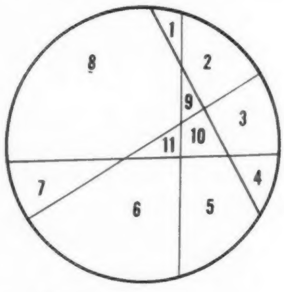


Cut the Circle

Into how many different pieces can a circle be cut by drawing only four straight lines across the circle?

Bob Yarbrough
Swainsboro (Ga.) H. S.

Answer: The circle can be cut into eleven pieces as shown in the figure below. Can you tell whether this is the greatest number of pieces?



Candle in Space

Suppose there are two identical candles, one in outer space and one on the Earth, and each candle is enclosed in an airtight glass tube. Both tubes are the same size. If the candles are lit, which one will be extinguished first, the one in space or the one on Earth?

Robert Klinger
Macombs Jr. H. S.
Bronx, New York

Answer: When the candle on Earth burns, the Earth's gravity pulls the carbon dioxide generated by the flame down to the bottom of the tube, so that the oxygen, which is lighter than the carbon dioxide, remains at the top of the tube and feeds the flame. However, in outer space, where there may be little or no gravity, the carbon dioxide would stay near the top of the tube and quickly suffocate the flame. Therefore, the candle on Earth would stay lit longer than the candle in space.

Judges' Handshakes

There are nine Supreme Court Justices. If each were to shake hands with all the others, how many handshakes would take place?

William Linsman
Beverly Hills (Calif.) H. S.

Answer: There will be a total of 36 handshakes. The first judge shakes hands with the other eight, making eight handshakes. The second shakes hands with seven others, excluding the first judge, who already shook his hand. This makes seven handshakes. The third judge shakes hands with the remaining six, excluding the first two who already shook his hand. In this way the total number of handshakes is $8 + 7 + 6 + 5 + 4 + 3 + 2 + 1 = 36$. In this way every judge will have shaken hands with every other judge once and only once. In mathematics, such an arrangement is called a permutation. A permutation is one way of arranging a given set of things, without repetition. The above problem shows the number of ways in which nine judges can be arranged two at a time without repetition.

Send in Your Favorite Brain Teaser

You surely have a favorite brain teaser that you would like to share with other readers. Send the brain teaser, together with the solution, to Science World, *33 West 42nd Street, New York 36, N. Y. We will pay $5 for every brain teaser published. Include the name of your school, in addition to your home address, and state your age.*

Exploring Behavior

(Continued on page 43)

threw itself on the floor, or sat rocking back and forth clutching its body, crying and screaming. Given only the wire mother in the room, the baby monkeys were not in the least reassured by her presence. In fact, their distress became greater. When the cloth mother was there, however, the infant ran to her and clung tightly until its fear vanished. After a time, completely comforted and soothed, it was able to leave the mother and explore its surroundings.

"The monkey was now a normal, curious, happy baby," explained Dr. Harlow.

Dr. Harlow carried out studies with the same monkeys at a later age. He discovered that even though a monkey had been separated from its cloth mother for more than six months it still clung to her.

Monkeys deprived from birth of any mother—cloth, wire or real—grew up severely disturbed and unhappy. At the age of eight months, when given a cloth mother, they were unable to show any real love for her. From these experiments, Dr. Harlow concluded that there is a critical period of infant development during which affection is formed. In monkeys this is between the first 30 to 90 days. In humans this takes place during the first year—after the first three months. If the infant has not learned to love by then it may never learn to love.

"There can be no question that love is crucial to the development of security," Dr. Harlow concludes. "Security does more than make the infant confident. It emboldens him. It is as if he knew that the mother will protect him."

A past president of the American Psychological Association, Dr. Harry Harlow rarely has leisure time and is a man of few hobbies. The little leisure he has is spent playing tennis or bridge. He has four children, from six to twenty.

"One of the things that is most fascinating about research," Dr. Harlow explains, "is that there are no frontiers, no field of human endeavor that can not be attacked systematically and experimentally—even one as elusive as love. There are countless areas still unexplored, which remain to be studied by tomorrow's scientists."

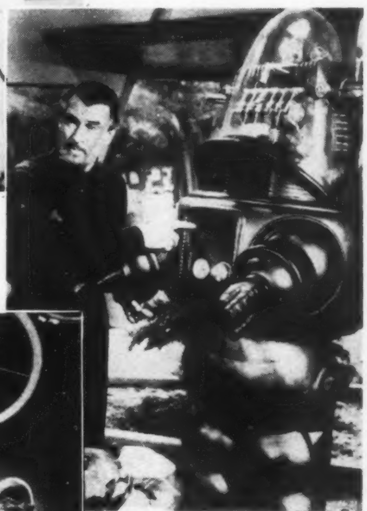
Today, when science probes the vast reaches of outer space, it is reassuring to know that scientists are also groping hopefully for an understanding of what may be the greatest riddle of all—the behavior of man.

—Frances Gudemann

Sci-fun

From "A Journey to the Center of the Earth"

Begorra! It really *is* Roger Ackroyd!



From "Lost Planet"

Why can't he play outside with the other kids?

From "Conquest of Space"

I can't seem to relax. Next time I'm taking the bus.

From "The Dam Busters"

Are you sure you don't feel a draft in here?

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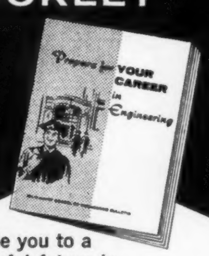

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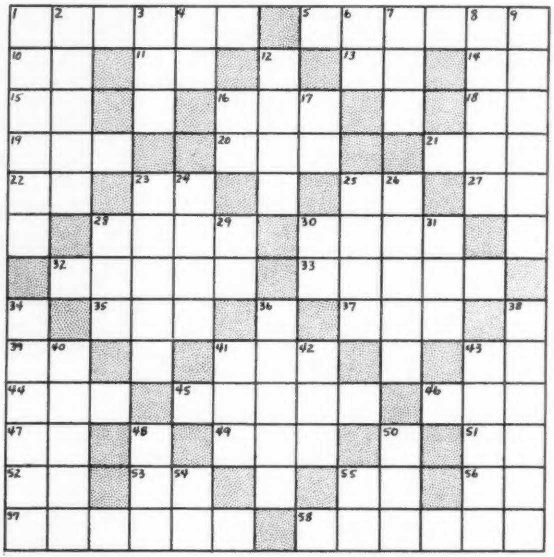
Exploring the Elements

By Mark Lewis Berch, Paul Junior High School, Washington, D. C.

★ Starred words refer to chemistry

Students are invited to submit original crossword puzzles for publication in Science World. Each puzzle should be built around one topic in science, such as astronomy, botany, geology, space, electronics, famous scientists, etc. Maximum about 50 words, of which at least 10 must be related to the theme. For each puzzle published we will pay $10. Entries must include symmetrical puzzle design, definitions, answers on separate sheets, design with answers filled in, and statement by student that the puzzle is original and his own work. Keep a copy as puzzle cannot be returned. Give name, address, school, and grade. Address Puzzle Editor, Science World, 33 West 42nd Street, New York 36, New York. Answers to this puzzle are on page 43.



ACROSS

- *1. Metallic element, atomic No. 76.
- *5. This element is used in dimes.
- *10. Colorless, odorless, inert gas (*symbol*).
- 11. Either, ______; neither, nor.
- *13. Abundant metal, No. 22 (*symbol*).
- *14. Highly reactive, silvery metal (*symbol*).
- *15. Rare earth element, No. 70 (*symbol*).
- 16. Two thousand pounds.
- 18. Anno Domini (*abbr.*).
- 19. This can be chewed over and over again.
- 20. Its capital is Montgomery (*abbr.*).
- 21. Science (*abbr.*).
- 22. Electromagnetic (*abbr.*).
- *23. Symbol for 5 Across.
- *25. Lightest metal element (*symbol*).
- 27. "Et ______, Brutus?" Caesar said.
- 28. Passenger railway car.
- 30. Money paid to a landlord.
- 32. Stiff or unyielding.
- *33. Radioactive, gaseous element, atomic weight 222.
- 35. Negative adverb.
- 37. Loud, confused noise.
- 39. An exclamation.
- 41. Permit.
- 43. Agricultural Engineer (*abbr.*).
- *44. At 1,000° F. metal is ______ hot.
- *45. Non-metallic element obtained in either amorphous or crystalline form.
- 46. Bundle (*abbr.*).
- *47. Element of atomic No. 83 (*symbol*).
- 49. Gross (*abbr.*).
- 51. Roman number two.
- 52. Outside dimension (*abbr.*).
- *53. Forms poisonous compounds (*symbol*).
- *55. A noble element (*symbol*).
- *56. Rare earth element, No. 63 (*symbol*).
- *57. Metal allied to iron and cobalt.
- *58. Element of atomic No. 49.

DOWN

- *1. A gas which forms 21% of the atmosphere.
- 2. Fatty secretion of sebaceous glands.
- *3. H^+ = hydrogen ______.
- *4. Alternate abbr. of uranium.
- 6. Third person pronoun.
- 7. Part of the mouth.
- 8. Make into a law.
- *9. Element discovered by P. and Mme. Curie.
- *12. Yellow, precious element.
- *16. Element of atomic No. 73, resembles platinum (*symbol*).
- *17. Same as 14 Across.
- *23. Inert gas used in tungsten bulbs.
- 24. Manner of walking.
- *25. Element whose symbol is Pb.
- 26. Nehru is Prime Minister of this country.
- *28. Metallic coating on cans.
- *29. Element, atomic No. 101 (*symbol*).
- 30. Railroad (*abbr.*).
- 31. 2,000 pounds.
- *34. Most widely compounded element.
- 36. Earth (*Latin*).
- *38. Lightest inert gas.
- 40. Title and main character of novel by Johanna Spyri.
- 41. Ship's diary.
- 42. Also.
- 43. Good-bye (*French*).
- 48. Type of tree.
- 50. Soft, wet earth.
- *54. Gray, crystalline, non-metallic element of sulfur group (*symbol*).
- 55. Anonymous (*abbr.*).

Mightiest Magnet

(Continued from page 16)

To obtain accurate readings, the plane must fly at extremely low altitudes—sometimes only 500 feet above the ground. The plane must fly in perfectly straight lines over the area being studied. A deviation of an eighth of a mile or less might destroy a flight's usefulness.

The pilot follows his course like a farmer plowing straight furrows. He flies along a straight line, perhaps for 25 miles, banks the plane and moves over a quarter mile, then flies back 25 miles parallel to the first line. In this way, large areas can be prospected in a few weeks, where ground prospectors might take months or years. For example, the U. S. Geological Survey made a mile-by-mile analysis of the entire state of Indiana from the air, and Aero Service Corp., a private company, has studied the entire area of Surinam, the Dutch possession in South America.

But geophysicists are no longer content to study the magnetic field on the Earth's surface. Today they are measuring the Earth's magnetism in space, with magnetometers carried aloft in rockets and satellites. These measurements are important because they are helping to determine the shape of the lethal radiation belt which surrounds the Earth—the Van Allen belt.

Van Allen Radiation Belts

The Van Allen belt was discovered in 1958 by Dr. James A. Van Allen, a physicist of the State University of Iowa. For years he had been studying cosmic rays in the upper atmosphere by shooting up Geiger counters in the nose of "rockoons"—rockets carried aloft by balloons before being fired.

The data which the rockoons radioed back to Earth revealed some puzzling results. At high altitudes, near the Equator, the counting rate seemed to drop to very low levels. This was puzzling, since the cosmic rays should have increased in intensity at higher altitudes. More Geiger counters sent up in the Explorer I and III satellites merely confirmed this. At 500 to 600 miles above the Equator, the radiation count would drop nearly to zero.

One day as Van Allen and his staff were pondering these results, the answer to the problem was casually suggested by one of his fellow scientists. He reminded them of something they all knew but had forgotten: A sufficiently high level of radiation could jam the counter, so that the counting rate would register as zero. Van Allen's Geiger counters had discovered a tremendously high level of radiation, not a lack of it. It seemed that "space" was radioactive.

Eventually it was found that this intense radioactivity was caused by high speed particles trapped by the Earth's magnetic field in a belt that was thickest around the Equator. The particles travel in corkscrew motion at high speed between the poles, along the magnetic lines of force.

Such discoveries as the Van Allen belt and magnetic storms are really studies of the Earth's relationships to the sun. The sun's energy, radiation, and particles exercise a great influence on the Earth and on the atmosphere which envelops it. On the other hand, the Earth's atmosphere and magnetic field have strong effects on the emissions from the sun which collide with our planet.

If cosmic rays, geomagnetism, auroras, the ionosphere, and the sun were examined separately they would remain a puzzle forever. But studied together, they provide new insights into the structure of our complex planet.

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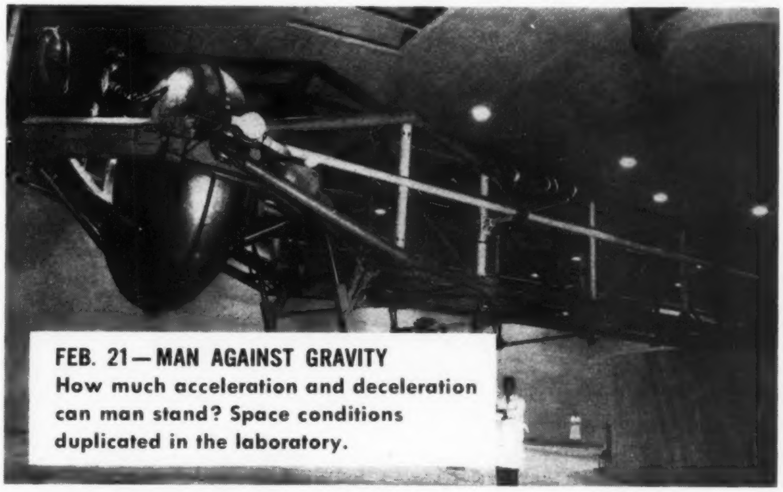

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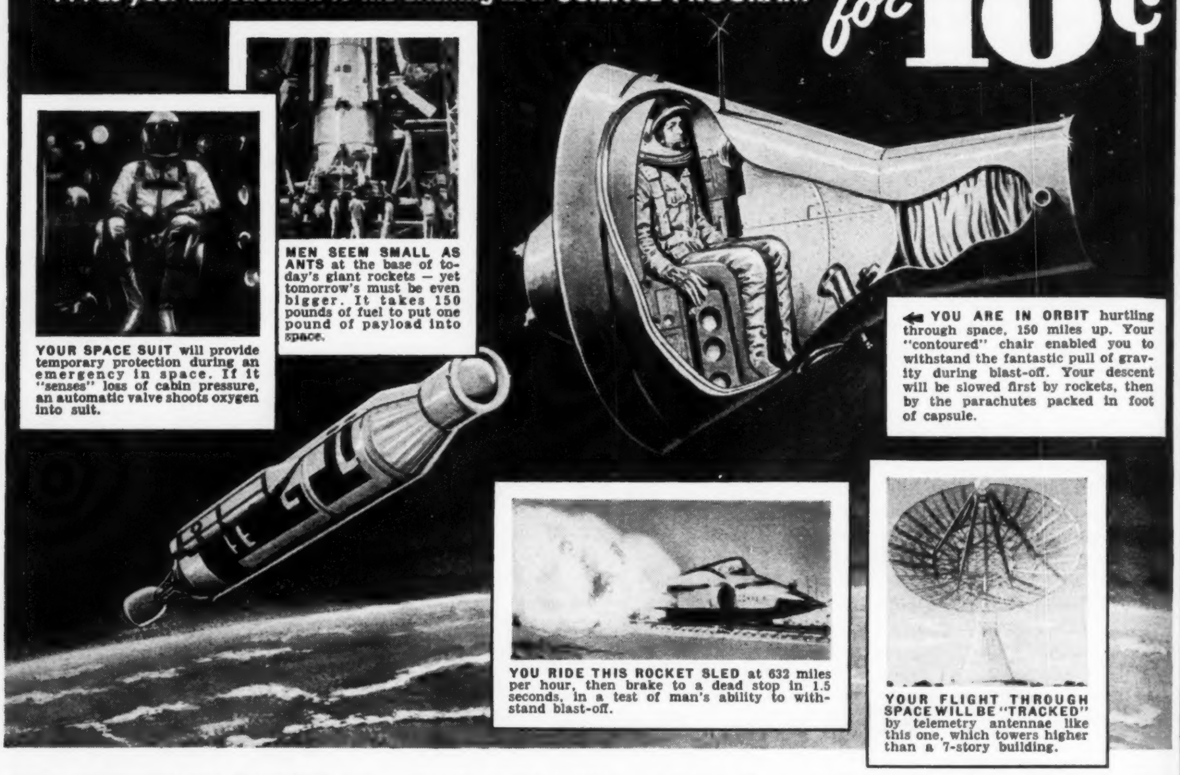

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SC-11YP

Science and the K-12 Program

THE 1960 Convention of NSTA at Kansas City, Mo., has a two-fold aim: to present a unified view of the total science program within American education, and to create an awareness of recent developments in scientific research through the "Frontiers of Science" series. The activities in this year's program have been expanded. Advance reservations by mail are urged.

Frontiers of Science

"Frontiers of Science" is a series of addresses focusing attention on recent developments in several of the major fields of science. The first speaker will be Dr. Linus C. Pauling, Nobel Laureate, Professor of Biochemistry, California Institute of Technology, Pasadena; and Dr. John R. Heller, Director, U.S. National Cancer Institute, will give the second presentation. At the banquet on Friday evening, Dr. George B. Kistiakowsky, Science Advisor to the President of the United States, will be the principal speaker. These talks will be presented in general sessions. Thursday's B-I-E Luncheon address will also be related to the Frontiers series. The featured speaker is Dr. Walter H. Brattain, Nobel Laureate, Physical Research Department, Bell Telephone Laboratory. Additional frontiers in science will be explored by scientists meeting in five parallel sessions on Friday at 1:30 p.m.; all will be repeated at 3:30 p.m.

K-12 Science Programs

Problems and issues, development, teacher education, and the total school program as related to science in the kindergarten through the twelfth grade comprise the topics scheduled for study in the Curriculum Section of the NSTA Convention. Speakers, symposia, and panels implement the program. The program includes Dr. Robert H. Johnson, Superintendent of Jefferson County Public Schools, Lakewood, Colorado; Dr. Leona M. Sundquist, Chairman, Department of Science, Western Washington College, Bellingham; Dr. Joe Zafforoni, Professor of Science Education, University of Nebraska, Lincoln; and Dr. John H. Fischer, Dean, Teachers College, Columbia University, New York City.

Registration

Pre-Convention registration by mail is strongly urged and will be accepted through March 11, 1960. Do not mail forms and checks after this date since processing prior to the convention cannot then be assured. Receipts will be sent promptly when advance registration and reservations, accompanied by remittance in full, are received in the NSTA headquarters office. Bring these receipts to the convention and present them at the Advance Registration Table in the Municipal Auditorium to receive identification badge and tickets. Make checks payable to NSTA and send to National Science Teachers Association, 1201 Sixteenth Street, N.W., Washington 6, D. C.

Registration fee is $3 for the entire convention, or $1 for daily registration to accommodate those who can come only one or two days. *Registration is required for participation in all convention activities.* Those registering in advance, but unable to attend the convention, may receive refunds by sending their official receipts to NSTA headquarters before April 18, 1960.

Science Workshops

Within the framework of developing a continuous science curriculum, workshops for the 1960 Convention have been expanded to include groups for teachers in the primary grades, the intermediate grades, junior high school, and for supervisors. Four different areas of science will be considered:

1. Teaching about Plants and Animals and How They Grow
2. Teaching about Electricity and Magnetism
3. Exploring the Changing World
4. Using Special Resources in Teaching Science

Between the general orientation session on Thursday and the "exhibit" session on Saturday morning, there will be two two-hour work sessions in which materials will be used, constructed, and carefully considered in relation to problem solving and other aspects of classroom instructions.

Attendance will be limited to 20 persons in each workshop group; the fee is $3. Groups will be set up as registrations and fees are received.

Exhibits

Approximately 100 commercial exhibits will be presented in the annual Exposition of Science Teaching Materials in the Kansas City Municipal Auditorium. Plan to stop by and see the largest array of textbooks, laboratory furniture, equipment, apparatus, business-sponsored materials, audio-visual aids, and other materials displayed at an NSTA convention. The exhibits will be open after 9:00 a.m., Wed., March 30.

Science World will be found at Booth 90. A cordial invitation is extended to all teachers using *Science World*. Stop by and let us say "hello."

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NSTA Youth Director

Appointed recently as Director of Youth Activities, under the National Science Teachers Association's Future Scientists of America Foundation program, is William P. Ladson of Alexandria, Virginia. In this new position, Mr. Ladson will be working directly with NSTA's Standing Committee on science education activities for youth, the FSAF Administrative Committee, and NSTA's representatives on the editorial board of *Science World*. The development of a program for Future Scientists of America youth activities, services, and organization is a new NSTA goal and is now to take shape.

The new director of these activities, Mr. Ladson, was formerly head of the science department and chemistry teacher at Fairfax County Groveton High School, Fairfax, Virginia. Born in 1929 in Washington, D. C., Mr. Ladson now resides, with his wife, Claire R., and their four-year-old son in Alexandria, Virginia. He graduated from Mount Vernon High School in Alexandria in 1946, completed his BS Degree in Chemistry in 1953, and his Master's Degree in Education and Administration at the University of Virginia, Charlottesville, in 1958.

His teaching experience of six years began at Waynesboro High School, Virginia, in 1953. His activities comprise association with a number of educational associations, including the Fairfax County Federation of PTA, the Virginia Education Association, and Phi Delta Kappa. During the past year he was selected as the typical teacher and featured in the Fairfax County Board's annual report. His experience covers a wide background in science clubs, science fairs, summer programs for youth, summer institutes coordinator, and related public relations work in education.

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White House Conference

The Golden Anniversary White House Conference on Children and Youth is to be held March 27-April 21, 1960, in Washington, D. C. The purpose of the conference is "to promote opportunities for children and youth to realize their full potential for a creative life in freedom and dignity." The first of these conferences was called by Theodore Roosevelt in 1909. They have been held every ten years since then.

Conference participants will include representatives of state committees and national organizations, 700 young people, national leaders, and 500 international guests. NSTA's representatives are Sydney Blum, science specialist, Baltimore City Schools, Maryland, and Robert H. Horn, of the faculty of Waynesboro High School, Waynesboro, Virginia.

Museum to Conduct Summer Institute

High school teachers of earth science and biology are invited to apply for participation in a Summer Institute to be conducted by the Department of Public Instruction of The American Museum of Natural History at the Museum's Southwestern Research Station in Portal, Arizona, from July 5 through August 2, 1960. The program is being sponsored by the National Science Foundation.

The Institute will consist of two courses, *Techniques and Methods in Field Geology* and *Techniques and Methods in Field Zoology*. They will be conducted by instructors from the staff of the Museum's Department of Public Instruction. Participants will be required to take both courses, the successful completion of which will entitle them to six graduate credits from the College of the City of New York.

The geology course will embrace structure, stratigraphy, paleontology, and geomorphology, the methods of recording field data and the techniques of field mapping. The zoology course will include field observations, the latest techniques in collection and preservation of specimens, the use of keys in identification, and the assembling of scientific data.

The National Science Foundation grant to the Museum will cover participants' tuition, board and lodging, major transportation costs, and a specified allowance for dependents.

Applications will be accepted from high school teachers within the United States who do the major part of their teaching in earth sciences or biology. The group will be limited to 20 who will be selected by a special Museum committee.

Further information and application forms may be obtained by writing to C. Bruce Hunter, Director, Summer Institute in Field Geology and Field Zoology, The American Museum of Natural History, 79th Street and Central Park West, New York 24, N. Y.

U-M Awards For Graduate Study

The University of Michigan has received a $277,800 grant from the National Science Foundation for a fifth Academic Year Institute.

Under the terms of the grant, the University will award stipends to 48 high school teachers so they may study at the U-M for graduate degrees in chemistry, physics, or mathematics. The awards amount to $3,000 each, plus allowances for dependents, books, and travel.

Most of the teachers under the U-M program will be working toward a Master of Arts degree in the teaching of science.

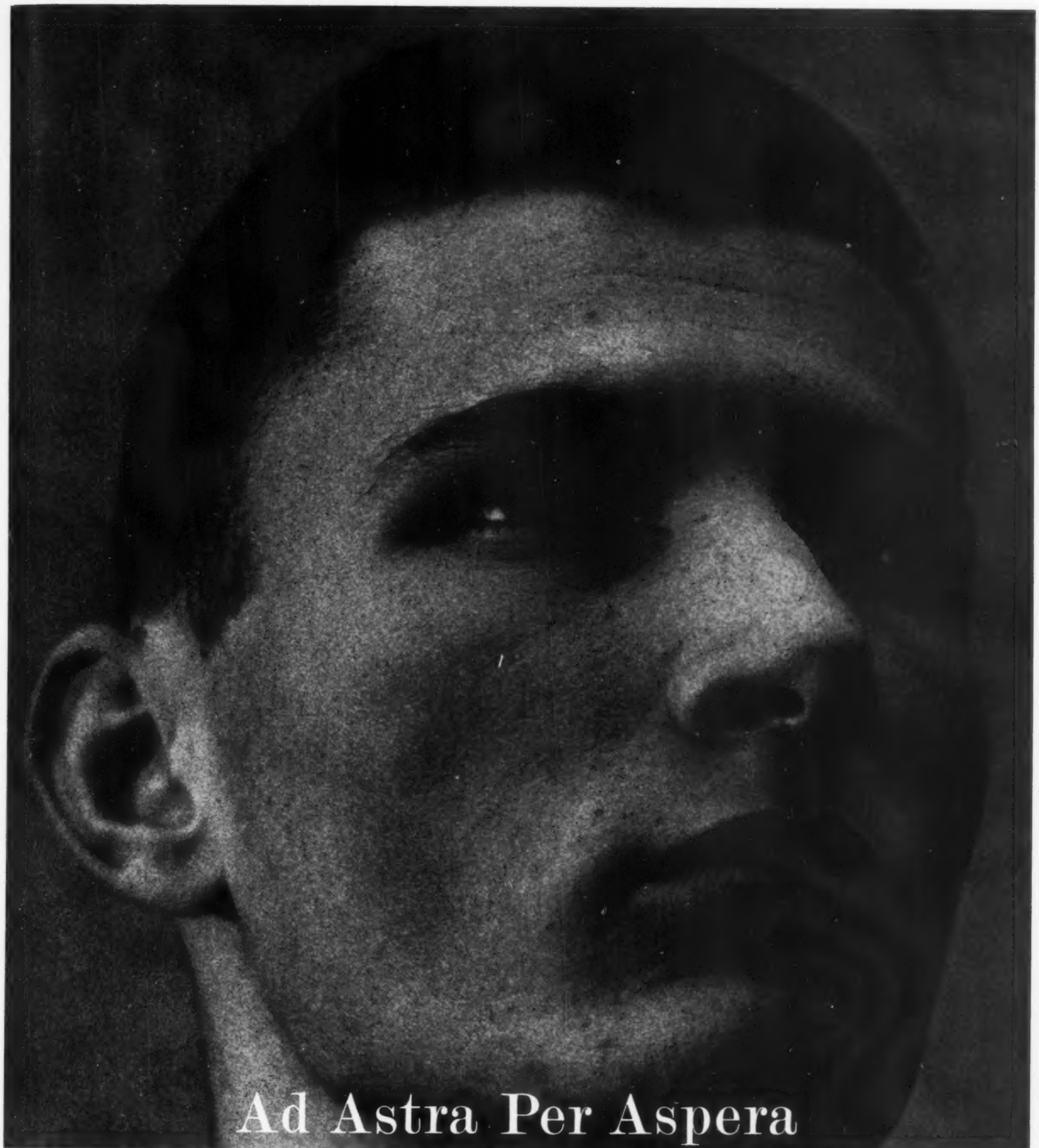
Besides the regular awards, 18 individual grants for summer study are available.

These consist of $300 for the term, plus allowances for subsistence and books.

Teacher-students participating in the program may take any group of science courses outlined by their advisers.

The U-M was one of 33 colleges and universities which received grants totaling about $9.2 million for the 1960-61 Academic Year Institute. The grants provide for about 1,600 new individual stipends. Some 3,400 teachers have taken part in the four preceding years of the program. Its purpose is to help teachers improve their subject matter knowledge through a year's advanced study on a full-time basis.

Teachers interested in further details of the 1960-61 AYI program at the U-M should write Professor Anderson, Chairman of the Department of Chemistry, 1018 Angell Hall, Ann Arbor.



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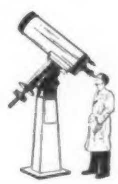

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